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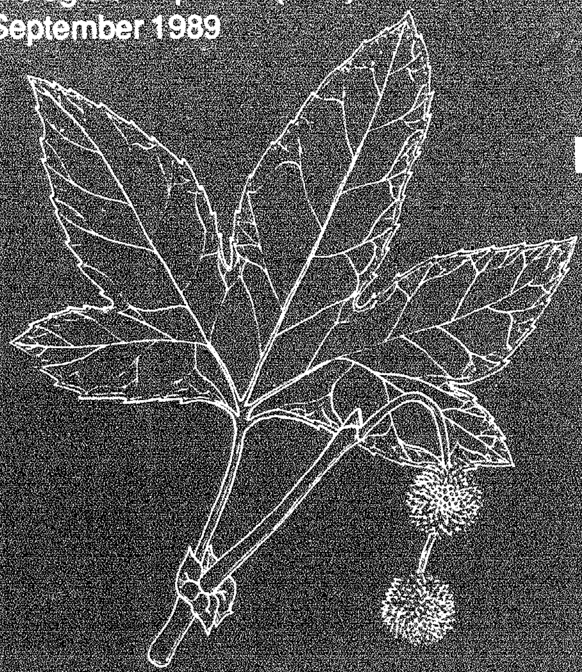
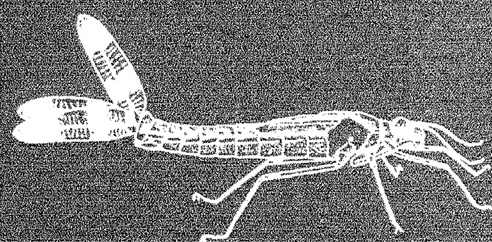
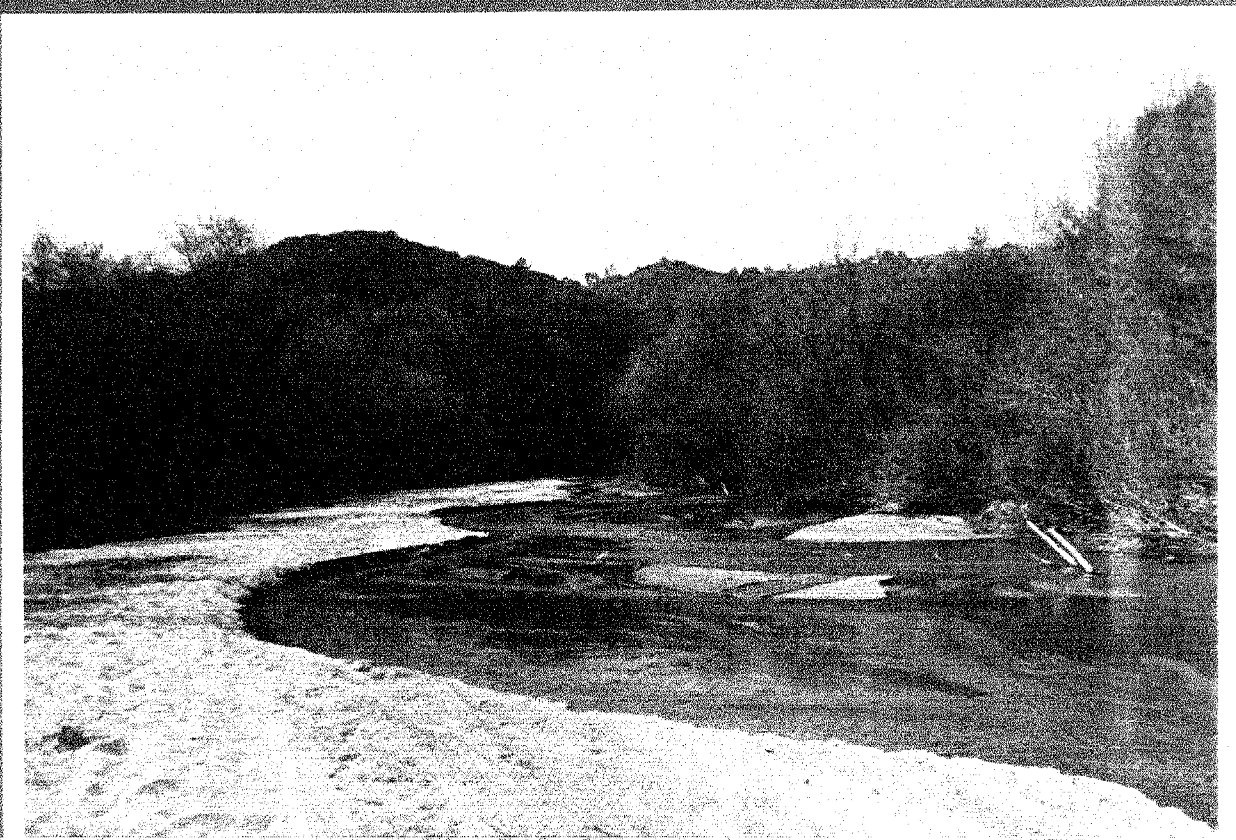
September 1989



THE ECOLOGY OF RIPARIAN HABITATS OF THE SOUTHERN CALIFORNIA COASTAL REGION: A COMMUNITY PROFILE





Fish and Wildlife Service
U.S. Department of the Interior

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Cover: Top left, drawing of California sycamore by W. Bailey; top right, drawing of predaceous nymph of the California spreadwing; photograph of the Santa Margarita River which has the least disturbed riparian habitat in San Diego County.

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THE ECOLOGY OF RIPARIAN HABITATS OF THE SOUTHERN CALIFORNIA COASTAL REGION: A COMMUNITY PROFILE

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PREFACE

This description of the riparian community of Southern California is a part of a series of profiles describing the coastal habitats of the United States. Its purpose is to describe the structure and functioning of the riparian habitat in Southern California. Cowardin et al. (1979) classify this habitat as occurring in the California province, estuarine, riverine, and palustrine systems.

The profile brings together a wide range of information on the physical and biologic features of the riparian community in Southern California and some practical information on governmental jurisdictions and habitat restoration. Most of the riparian type of habitat has been lost in the past one hundred years from human activities, though determining the amount remaining was beyond the scope of this profile. Added as an appendix are sites within the study area where examples of riparian habitat remain and can be visited by the public.

Information in this profile will be useful to land managers, resource planners, environmental consultants, ecology students, and interested citizens. The level of presentation, format, and style should make the profile useable for a diversity of needs from managing the land to preparing reports for classes or public presentations.

Chapter 1 defines the concept of riparian and outlines the profile study area; Chapter 2 describes the physical setting and some of the geofluvial processes; Chapter 3 outlines the effect of water regime on the establishment and succession of plant communities and describes the most common species of riparian plants; Chapter 4 details the fauna that is dependent upon and that uses the riparian habitat; Chapter 5 summarizes some of the ecosystem processes and values; Chapter 6 spells out the myriad of governmental jurisdictions and relationships that affect the use of and the ability to conserve this habitat type; and Chapter 7 presents information on riparian habitat restoration including a number of case studies.

CONVERSION TABLE

Metric to U.S. Customary

Multiply	*By*	*To Obtain*
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (° C)	1.8 (° C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces	28.35	grams
pounds (lb)	0.4536	kilograms
pounds	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (° F)	0.5556 (° F - 32)	Celsius degrees

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At the National Wetlands Research Center, Beth Vairin edited the manuscript, Daisy Singleton prepared the camera-ready copy, and Sue Lauritzen designed the layout.

Errors and omissions are the sole responsibility of the authors. Ed Keller was primarily responsible for Chapter 2; Barbara Massey for Chapter 4; Anne Sands and Phyllis Faber, in association with Bruce Jones, Environmental Consultant, for Chapter 6; Anne Sands for Chapter 7; and Phyllis Faber for Chapters 1, 3, and 5, Appendix D, organization, editing, and photographs unless otherwise noted. Plates in Chapter 2 were drafted by D.G. Crouch. Wendy Bailey was responsible for the drawings in Chapter 3 and for redrawing several figures. Sally Porter typed much of the manuscript. Nora Harlow typed several tables and did final editing. The authors are grateful to each of these people.

CHAPTER 1. INTRODUCTION

1.1 INTRODUCTION

Annual flooding, with accompanying overflows of streams and rivers, predates man's presence in California. In the 200 years since California's settlement by Europeans, almost every river in Southern California has been channelized or dammed to allow development on the floodplains. Only recently has there been concern about the loss of a highly productive and diverse ecosystem, capable not only of supporting a rich assemblage of plants and animals, but also of fulfilling other roles yet poorly understood. Perhaps as much as 95 to 97 percent of the riparian community has been eliminated in floodplain areas of Southern California, yet remnants remain, particularly at higher elevations where development pressures have been less intense.

This community profile assembles the small amount of information available on the riparian habitat of Southern California, an important but neglected habitat type. It has not been possible to establish definitive values for losses of riparian habitat or for the extent of remaining riparian habitat. The earliest aerial photographs of the Los Angeles Basin, taken in the late 1920s by Fairchild, show that the San Gabriel, Los Angeles, and Santa Ana Rivers were already channelized by that date. Vegetation can be determined on recent infrared aerial photographs; however, it is beyond the scope of this study to differentiate between quality habitat with native trees and an undisturbed or intact understory and disturbed or degraded habitat with exotic plant or tree species and little or no understory. The difference is of extreme importance in determining wildlife values, but extensive ground checks of aerial photographs are necessary for this kind of determination.

1.2 RIPARIAN HABITAT DISTRIBUTION

Riparian habitat occurs along streambanks where soils are fertile and water is abundant, at least for some portion of the year. It often appears as a deciduous greenbelt along perennial and intermittent watercourses and their floodplains.

The riparian community is a complex ecosystem. In the introduction to <u>Riparian Resources of the Central Valley and California Desert</u> (1983), Warner develops a riparian glossary based on the Latin word <u>ripa</u>, meaning bank or shore of a stream or river. The original meaning has been retained and the adjective "riparian" is defined as pertaining to the terrestrial or emergent zone (as opposed to aquatic or submerged zone) immediately adjacent to freshwater (<u>Dictionary of Geological Terms</u>, 1962; <u>Webster's Third New International Dictionary</u>, 1963). Although current usage sometimes expands the meaning of "riparian" to include tidal and estuarine zones, this study generally adheres to the original usage of the term, restricting it for the most part to a zone adjacent to a freshwater stream or river, recognizing that wildlife usage of habitat areas transcends technical definitions of habitat types.

Amphibians, reptiles, birds, and mammals all move back and forth across the riparian zone from streams into adjacent wetland and upland areas. Primary and secondary production derived from upland and riparian communities goes into streams and rivers, nourishing aquatic organisms that in turn support riparian organisms. In other words, the riparian community is interdependent with adjacent aquatic and upland communities. Two riparian birds, the dipper and the kingfisher, provide examples. The dipper feeds on aquatic stages of insects (dragonflies, damselflies, midges, caddisflies, etc.) that are nourished and protected by riparian vegetation; the kingfisher inhabits the riparian community but feeds on fish in an aquatic community that, in turn, feed on terrestrial insects from the adjacent riparian community.

Warner defines the adjective "riparian" as "pertaining to the banks and other adjacent terrestrial (as opposed to aquatic) environs of freshwater bodies, watercourses, and the surface-emergent aquifers (springs, seeps, oases) whose transported waters provide soil moisture significantly in excess of that otherwise available through local precipitation." An upland community, as opposed to a riparian community, is then defined as one above a floodplain in a zone far enough above or away from the transported waters of freshwater bodies, watercourses, and surface-emergent aquifers to be entirely or largely dependent upon local precipitation for its water supply.

Riparian habitat is usually seen as an ecotone, a transitional community between an aquatic and an upland community. Immediately adjacent to the watercourse, in contrast with those of the adjacent upland community, plants are taller, have larger leaves, and are often deciduous. As a result of its dependence on a supplemental water source, the riparian community is intimately tied to the meanderings of stream and river watercourses. As a functioning ecosystem, it is open and has high energy, nutrient, and biotic interchanges with aquatic systems on the inner margin and upland terrestrial systems on the outer margin. The boundary between upland and riparian communities shifts in years of high or low rainfall as flooding, sedimentation, and water table levels vary. Warner (1983) claims that riparian conditions exist to approximately the 100-year flood zone. Where streams are intermittent to ephemeral, the upland boundary is increasingly difficult to discern. The presence or absence of certain plants or their overall size relative to those in an upland setting becomes the easiest determining factor.

A riparian zone provides a classic case of the ecological principle of "edge" effect. Both density and diversity of species tend to be higher at the land/water ecotone than in adjacent upland communities. Many animals move from one community to another to forage, rest, or build nests. Large animals require access to streams for survival. In addition, a contiguous riparian strip provides a natural highway along which animals can move safely from one place to another. Increasingly, riparian corridors are valued by urban dwellers in that they provide a welcome relief from urban industrial and agricultural development. The soil and vegetation also provide a natural filtering system for removing air pollutants, a subject of increasing importance, particularly in the densely populated urban centers of Southern California.

1.3 DISTURBANCE EFFECTS

Disturbances of the riparian ecosystem are sometimes reversible. Irreversible alterations of the riparian ecosystem result from the diversion or loss of transported water to the system through diking, damming, channelization, levee building, or road construction. Clearing for crops, grazing, or golf courses is potentially reversible as long as the water supply remains unaltered. The cumulative effects of land clearing (agricultural and urbanizing), earth moving (water diversion and sedimentation), and pollutants (pesticides, herbicides, organic chemicals) all result in a less vigorous and deteriorating ecosystem with reduced functions and altered plant and animal populations.

1.4 CLASSIFICATION SYSTEMS

In the U.S. Fish and Wildlife Service's (USFWS) Classification of Wetlands and Deepwater Habitats of the United States, by Cowardin et al. (1977), habitats are classified according to hydrologic and geomorphic factors to which vegetation types are related. Using this system, riparian habitat can be found in the estuarine, riverine, and palustrine categories. This community profile of riparian habitat in Southern California includes segments of the palustrine system, defined as nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand. The USFWS classification system is not entirely satisfactory for defining "riparian" as it does not appear to take into account the effect of high water tables in floodplain areas that significantly determine the assemblage of plants in riparian habitat. An example of the use of this classification system can be found in Appendix 1 of Onuf (1983).

The California Natural Diversity Base, in a modified version (1983) of an Outline of California Natural Communities by Cheatham and Haller (1975), recognizes riparian habitats as a major category, with divisions and subdivisions based on geographic and vegetational differences. The categories applicable to the riparian habitat of Southern California are

- Bottomland Forest and Savanna
  - Cismontane Bottomland Forest
    - Coast Live Oak Bottomland Forest
    - Arroyo Willow Bottomland Forest
    - Black Cottonwood Bottomland Forest
- Riparian Forest
  - Cismontane Riparian Forest
  - Southern Riparian Forest
- Alluvial Woodland
  - Sycamore Woodland
- Alluvial and Riparian Scrub
  - Willow Scrub
  - Cismontane Willow Scrub
  - Mule Fat Scrub

1.5 STUDY AREA

Southern California, as defined in this community profile, covers the cismontane or coastal area between the Coast Range Mountains and the sea as shown in Figure 1. The study area is bounded on the north by Point Conception in Santa Barbara County

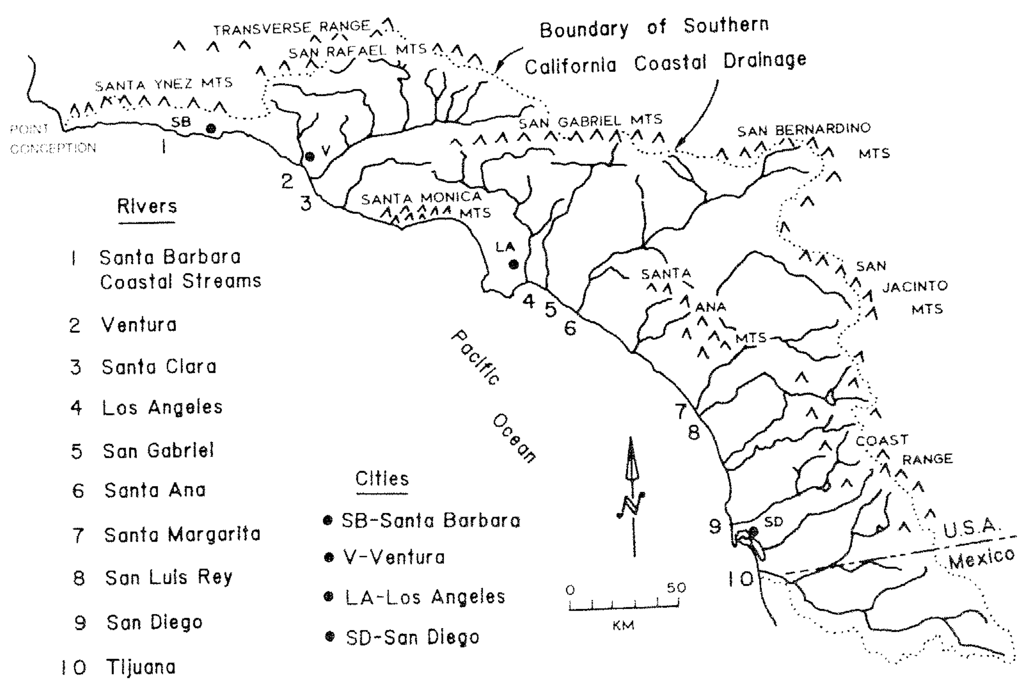


Figure 1. Study area showing major coastal drainages in Southern California.

and extends eastward along the crest of the Santa Ynez Mountains in the Transverse Range, along coastal-draining portions of the San Rafael Mountains drained by the Ventura and Santa Clara Rivers, across the San Gabriel and San Bernardino Mountains, both drained to the west by major rivers, the Los Angeles, San Gabriel, and Santa Ana, all crossing the vast Los Angeles floodplain. The study area then continues southeast to the Mexican border in the cismontane area from the crest of the San Jacinto and Santa Ana Mountains and the Coast Range in Orange and San Diego Counties to the Pacific Ocean. The Santa Monica Mountains are included within this region, and brief mention is given to the Channel Islands, considered to be a westward extension of the Santa Monica Mountains.

CHAPTER 2. PHYSICAL SETTING AND PROCESSES

2.1 INTRODUCTION

Human use and interest in the riverine environment of Southern California extends back more than one hundred years. Particularly in the last eighty years, rapid and extensive urbanization has significantly altered the Southern California environment, and streams and rivers have been extensively modified for the purposes of flood control and water supply. The Los Angeles River, which flooded during the storms of 1938 that killed 87 people while inflicting $78 million in damage, has been so altered as to scarcely resemble its natural conditions. For its size, the Los Angeles River may be the most extensively controlled river in the world. There are 290 check dams, 75 debris dams, 8 control and storage reservoirs, and 2 large flood-control basins in the 2,155 square kilometer drainage basin of the Los Angeles River (Brownlie and Taylor, 1981), and nearly 90 percent of the banks have been straightened and/or lined with concrete.

The total drainage area of streams and rivers in Southern California exceeds 32,000 square kilometers, of which about 53 percent is controlled by dams and reservoirs (Brownlie and Taylor, 1981). Figure 2 shows the Southern California drainage area and lists some of the major rivers.

Although we can sometimes control a river by constructing massive dams and channel works to dissipate the disastrous effects of floods and droughts, we still know too little about the processes by which natural river systems are formed and maintained. Only recently have we recognized that physical diversity in the natural system is necessary to maintain biological productivity and diversity, and that past modification of the riverine environment for human purposes has caused deterioration of riverine ecosystems.

In this chapter we present fundamental concepts necessary for understanding the fluvial system and discuss the nature and extent of human modification of the Southern California riverine environment.

2.2 THE FLUVIAL SYSTEM

The fluvial or river system may be discussed in terms of three major zones: (1) the erosion zone, where much of the sediment is produced in the headward portions of a drainage system; (2) the zone of storage and transport of sediment in the downstream or middle portion of the drainage system; and (3) the zone of deposition of sediment, which is usually a lake or ocean, as shown in Figure 3 (Schumm, 1972). Although this idealized system is useful in understanding general concepts about stream and river processes, there are many exceptions. Some exceptions are particularly common in Southern California because of the wide variation in physical conditions from the mountains to the sea.

The natural riverine environment also can be viewed as a system composed of three interrelated parts: the fluid or water; the main channel and floodplain; and the network of channels that makes up the drainage basin. As the system evolves and changes, all three parts will mutually adjust and influence the others. Adjustment involves a multitude of interactions that tend to maintain a delicate balance within the system. In most streams and rivers, that balance is a quasi-equilibrium (Leopold and Maddock, 1953) or dynamic

Figure 2. The Southern California drainage area showing annual runoff in inches (after California Water Atlas, 1979).

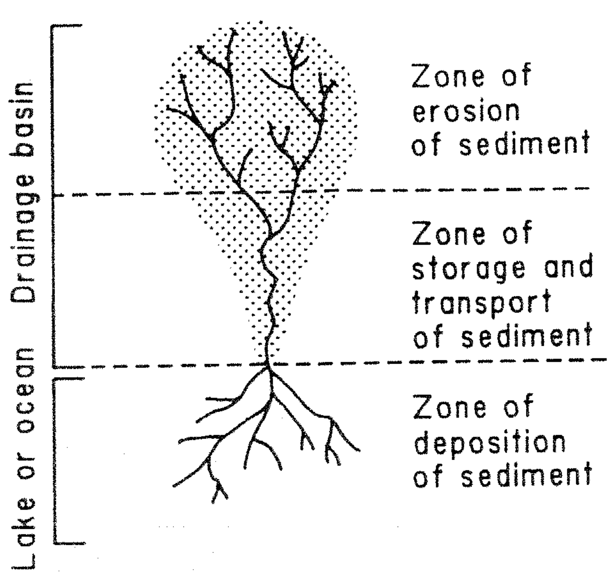


Figure 3. The fluvial system (modified after Schumm, 1978).

equilibrium (Hack, 1960). In order to understand the quasi-equilibrium or dynamic equilibrium, we must recognize that (1) the stream and river channels and adjacent floodplain comprise an erosional, transportational, and depositional environment in which form and process evolve in harmony; (2) significant changes in the fluvial system often occur when a threshold has been crossed; and (3) human interference with the fluvial system generally reduces the physical variability of the channel and floodplain, resulting in a loss of hydrologic variability and biological productivity.

2.3 BASIC CONCEPTS

2.3.1 Channel-Floodplain Environment

The stream or river channel and adjacent floodplain are part of a unique environment characterized by erosional, transportational, and depositional processes in the fluvial system. The floodplain, a part of the natural fluvial system, is produced by depositional processes during flows of moderate magnitude and frequency.

Formation and maintenance of the floodplain involves two main processes: (1) overbank flow and resultant vertical accretion of fine sediment; and (2) lateral migration of the stream channel with deposition and floodplain construction on the inside of bends. Which of these two processes dominates the formation and maintenance of a particular floodplain depends upon local conditions. In general, however, in highly meandering streams the rate of lateral migration may greatly exceed that of vertical accretion. In streams with stable meanders and little migration from side to side, vertical accretion may be the dominant process in the formation of the floodplain. In the steeper headwater portions of streams, floodplains may be lacking or poorly developed.

Under natural conditions a stream or river usually has sufficient discharge to emerge from its bank and flood adjacent areas on the average of once every year or two. Overbank flow often supplies water to adjacent lowlands on the floodplain, which serve as storage sites for ground water later released slowly to the stream during drier portions of the year. People living near rivers must recognize that overbank flows (floods) are a natural process of the fluvial system. To maintain the integrity of the fluvial system, the stream or river channel and adjacent floodplain must be considered a complementary system that has evolved in harmony over a period of years. Modification of the environment to reduce overbank flooding will reduce hydrologic variability and degrade the riverine environment. In recent years there has been a move away from absolute control of the river system to floodplain management, which involves zoning of the floodplain to reduce damage from the natural process of flooding.

2.3.2 Channel Pattern

The pattern of a stream or river channel as viewed from the air is called the channel pattern. Natural streams fall into two major types of channel patterns: (1) braided channels, characterized by an abundance of mid-channel islands or bars that continually divide and reunite the channel; and (2) channels that are not braided. Straight channels are rare in nature and are generally associated with geologic or structural control. Therefore, most non-braided channels are characterized by numerous bends and may be described as sinuous. A particular type of sinuous stream, characterized by very regular bends, is labeled a meandering stream. In the headward portion of streams, where the gradient is steep and controlled by the geology, channel patterns are difficult to distinguish, but generally are straight to sinuous and confined to a steep, V-shaped valley. After emerging from a mountain front, streams may flow across an alluvial plain and be either braided or meandering, depending upon the slope of the channel, the sediment load carried, and the hydrologic conditions. Streams with a high load of coarse sediment (gravel) and steep slope favor the braided pattern, whereas those with a lesser slope and gravel load are more likely to be sinuous. Streams emerging from a mountain front will often wander back and forth across the alluvial plain, producing a system of coalescing alluvial fans. In other cases, streams may cut across alluvial fans or plains and deposit their load directly in a lake or ocean without long-term storage of the sediment on alluvial plains.

2.3.3 Fluvial Hydrology

In most stream and river channels, the characteristic forms are produced by highmagnitude flows (floods) and may be modified or slightly changed only during lowflow periods. The principles of conventional hydrology apply during the low-flow period when the stream is essentially a rigid container for the fluid phase with little or no sediment transport. At high flow, when sediment is being eroded, transported, and deposited, conventional hydrology is no longer applicable because of the many variables (Leliavsky, 1966; Maddock, 1969). Thus it is necessary to distinguish fluvial hydrology from more conventional hydrology in order to understand the natural fluvial system and riverine environment.

Three important principles of fluvial hydrology are (1) in no part of the natural channel are contiguous streamlines (hypothetical lines that represent the direction of flow) parallel to one another or parallel to the banks of the channel; (2) the greater the curvature of the channel, the deeper the scour is likely to be; and (3) during high (bankful) flow events, scour is associated with horizontal convergence or narrowing of streamflow and deposition with horizontal divergence or widening of streamflow (Leliavsky, 1966). The third principle, illustrated in Figure 4, is known as the convergence-divergence criterion. It suggests that, in general, areas that converge during high-flow events will scour to form pools, while areas that diverge during high-flow events tend to be associated with deposition and the formation of bars or riffles.

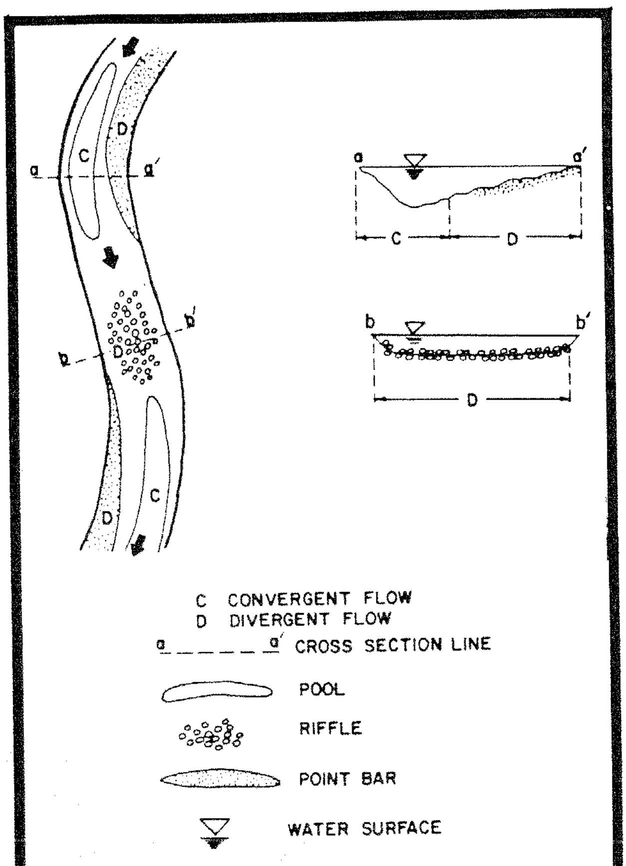


Figure 4. Idealized diagram showing areas of convergent and divergent flow.

2.3.4 Bed Forms

A bed form is any irregularity produced on the bed of a stream or river by the interactions between flowing water and moving sediment (Simons and Richardson, 1966). In most stream and river systems, two main types of bed forms may be present: (1) pools, riffles, point bars, and other bars that give the stream its basic morphology and generally are large enough to be measured in channel widths; and (2) ripples, dunes, and antidunes, which are primarily controlled by the hydrologic phase of the fluvial system and may not be a significant part of the basic channel morphology (Keller and Melhorn, 1973). Pools, riffles, and point bars are best developed in alluvial meandering streams with a gravel bed, whereas mid-channel bars and side-channel bars are probably best developed in braided channel systems. If there is an appreciable amount of finer bed-load material (sand), then ripples and dunes are more likely to be present, which at low flow may migrate through the channel system, partially masking more stable bed forms, such as pools, riffles, and point bars.

Pools, riffles, point bars, and mid-channel bars may be identified by basic morphology (Keller, 1971). Pools are topographic low areas (deeps) produced by scour (convergent flow) during high channel-forming events. Riffles are topographic high areas (shallows) produced by depositional processes (divergent flow) during high channel-forming events. Point bars are depositional forms located on the inside of meander bends. The pool and point bar together produce an asymmetric cross-channel profile, whereas the riffle often forms a more symmetric cross-channel profile (Figure 5). Other mid-channel and side-channel bars are formed by depositional processes during high channel-forming events. The best developed mid-bars and islands are associated with braided channels characterized by steep channel gradient and abundance of bed-load material being transported and deposited.

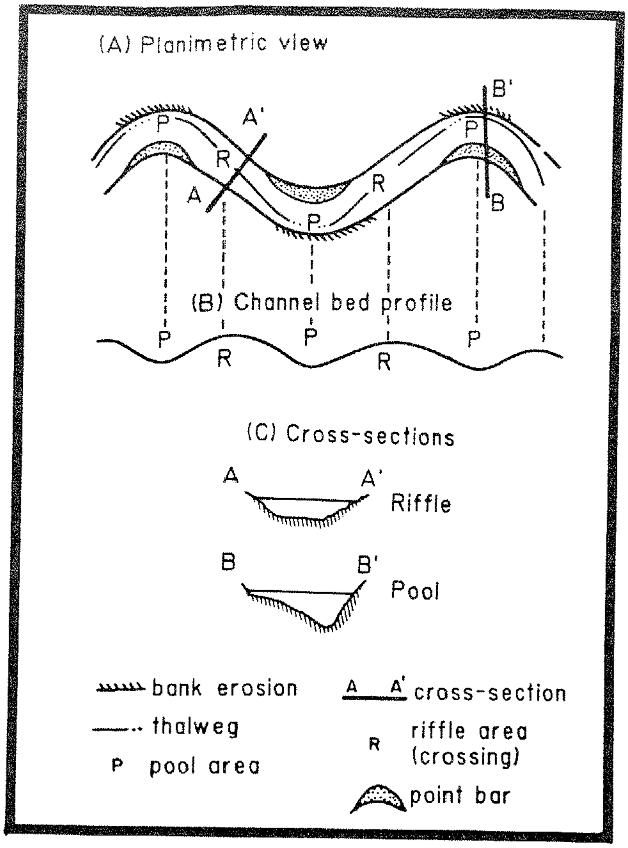


Figure 5. Pool-riffle morphology.

Pools and riffles are particularly significant bed forms in the riverine environment. At low flow, pools are characterized by slow, deep waters while riffles are characterized by fast, shallow waters. This hydrologic diversity meets feeding, breeding, and cover requirements for a wide variety of riverine organisms. At high flow, boulders in riffles may provide shelter for organisms that would be damaged by excessive water velocity in the stream channel. Pools and riffles sort stream gravels so that finer materials are found in pools and coarser materials in riffles; this sorting allows a wider variety of fish and aquatic insects to use the bottom of the stream channel for breeding, resting, and feeding. They also promote the development of a diversity of streambank vegetation. Tree-shaded pools and more sunlit riffles provide a diversity of cover and food for riparian organisms. Pools and riffles provide a diversity of sensory stimuli and physical and biological contrasts, such as shallow, bubbling water on riffles versus the slower water in pools, shaded versus sunlit water, and the different spectra of organisms that prefer one or the other.

Many stream and river channels are characterized by regularly spaced pools and riffles. In these channels, pools tend to remain in approximately the same location over a period of years, and such channels may be considered morphologically stable. In alluvial stream and river channels, as well as some bedrock channels, pools are most commonly spaced at about five to seven times the channel width. Riffles are found between pools and thus have a similar spacing. Adjacent pools and riffles form pool-riffle sequences, and many streams consist of a channel morphology dominated by regularly recurring pool-riffle sequences. Well-developed pool-riffle sequences are most commonly found in gravel-bed alluvial streams with a channel slope less than 0.01 (1 m drop per 100 m horizontal), but may also be found in bedrock channels and steep mountain streams. For the latter, pools are often associated with large amounts of organic debris or large in-stream boulders. In such streams there may not be a regularly spaced pool-riffle sequence because the spacing of pools is controlled by the organic debris or boulders. Most of the pools in the steep bedrock portions of streams in Southern California are of this type.

2.4 THRESHOLDS IN STREAM AND RIVER SYSTEMS

Many hydrologic and morphologic changes that take place in streams and rivers are in response to exceeded thresholds. In general, when a threshold is crossed, a change in process (for example, erosion to deposition) occurs. One of the better-known hydrologic thresholds in stream and river systems is that defined as the velocity necessary to initiate bed-load motion along the bottom of the stream or river channel. This threshold results from a positive feedback mechanism, since initiation of movement of bed-load particles facilitates movement of other particles. Another well-known hydrologic threshold occurs when the Froude number exceeds 1 (the Froude number is defined as the ratio of the inertial force to the gravity force of flowing water). When the Froude number is less than 1, flow is labeled tranquil, and there is a characteristic set of bed forms such as ripples and dunes. If the Froude number exceeds 1, then a threshold is crossed and the bed forms change to plain beds or antidunes.

Streams and rivers with well-developed pool-riffle sequences produce another type of hydrologic threshold that helps form and maintain these bed forms. Pools at low flow are characterized by deep, slow-moving water compared to riffles, where the flow is faster and shallow. However, at high flow, the opposite may be true; pools may have a higher velocity or flow of water than adjacent riffles. This process of hierarchical change of velocities in pools and riffles is described in Keller's (1971) hypothesis of velocity reversal and is shown in a generalized form in Figure 6. As discharge increases over the pool-riffle sequence, the initial velocity in the riffle exceeds that of the pool. However, with increasing streamflow to near bankful, a threshold is eventually crossed beyond which the velocity of water in the pool may exceed that on the riffle. The concept of velocity reversal is important in explaining why pools tend to scour at high flow and fill at low flow, whereas riffles fill at high flow and scour at low flow. The scour-fill pattern associated with velocity reversal is a hydrologic threshold characterized by negative feedback that allows pools and riffles to be maintained over a number of flows and years. The occurrence of velocity reversal or shear-stress reversal has also been documented by Andrews (1979) and Lisle (1979). However, the reversal apparently does not occur in all pool-riffle sequences. In some channels there is simply a convergence of velocities over the pool and riffle with increasing discharge. The effect of this is similar to that of reversal in that it will allow pools to scour.

Several thresholds also tend to control the morphology and channel pattern of a stream or river. Perhaps the best known of these are the threshold values of channel slope, which tend to control channel pattern (Figure 7). The major conclusion that may be drawn regarding these thresholds is that a change in channel pattern, rather than being continuous, tends to occur quickly as threshold slopes are exceeded (Schumm and Kahn, 1972). Following the change, feedback mechanisms tend to be negative or self-enhancing to maintain a quasi-equilibrium or dynamic equilibrium in the stream or river system.

As a final example of thresholds in the riverine system, consider the processes of lateral migration of a meandering channel in cohesive alluvial bank materials. Most lateral migration may occur by bank caving

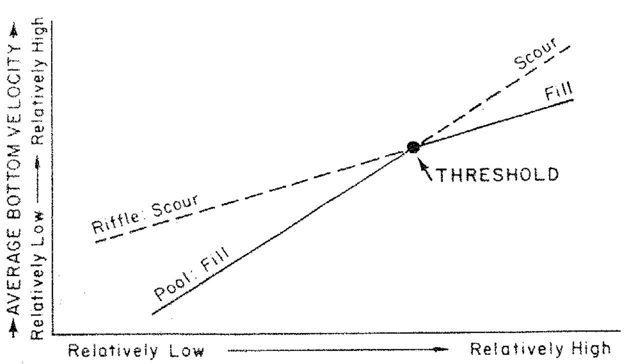


Figure 6. Hierarchical reversal of bottom velocity in a pool-riffle sequence. Data from Dry Creek near Winters, California (Keller, 1981).

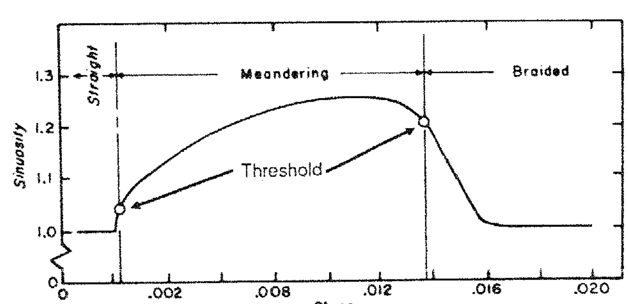


Figure 7. Threshold condition of slope controlling channel pattern (after Schumm and Khan, 1972).

or slumping following a high-flow event. Water during high flow is stored in the channel bank materials, and, following rapid drawdown of water during flood recession, this water is left unsupported and the shear strength of the bank materials is lowered. Often the drawdown is rapid enough that the shear strength of the materials falls below a critical threshold of stability and failure occurs. This particular threshold is a negative-feedback mechanism in the adjustment of channel slope that allows the stream or river to migrate laterally while maintaining a constant channel morphology.

Changes in sediment transport, bed form, and channel pattern may take place abruptly when a threshold is exceeded. Furthermore, changes that take place may be characterized by positive feedback, which tends toward a disequilibrium in the fluvial system or, more commonly, negative feedback, which tends to maintain the dynamic or quasi-equilibrium in fluvial systems.

2.5 HUMAN INTERFERENCE IN THE RIVERINE ENVIRONMENT

Human use of the riverine environment has included a variety of land-use changes to control the flow of water and sediment. Two of the more important alterations are channelization and the construction of dams and reservoirs. Channelization, whether called channel works or channel improvement, is a controversial practice because of the potentially adverse effects on the system ecosystem. Loss of fish and wildlife habitat to channelization is well documented in many instances. Many channelization projects control floods and bank erosion and improve navigation, but we are not always able to predict which projects are likely to cause unacceptable ecological damage. In general, channelization projects reduce the hydrologic and physical variability of streams and rivers, and the variability of biological communities as well. Figure 8 contrasts some of the differences between a natural channel and an artificial channel. Channelized streams are usually straighter, with poorly sorted stream gravels and less variability in depth and velocity of flow during low-flow periods. During high flow or floods, channelized streams have less variation in flow velocity and consequently less shelter for aquatic organisms. Channelization generally also reduces the aesthetic appeal of streams by reducing physical, biological, and visual diversity of the riverine environment.

Channelization is not necessarily undesirable, but channels must be carefully designed so that environmental degradation is minimized. This is best accomplished by designing channels to provide for physical and hydrologic variability similar to that found in natural channels (Keller, 1976). In other words, we must design with nature to minimize environmental degradation associated with channelization.

Construction of dams and reservoirs also may disrupt the riverine ecosystem. Reservoirs tend to trap sediment, and downstream from a reservoir the stream or river bed may become armored with a layer of coarse bed material as fine materials are removed from the system. Unless sediment is added below via tributaries, there will be an impoverishment of finer bed materials downstream from dams and a reduction in physical variability. Upstream from dams and reservoirs, deposition will occur as a flowing-water environment is replaced by a still-water environment. Construction of dams on rivers also blocks sediment that would otherwise reach the coastal environment, and beaches may be deprived of their natural supply of sediment. Dams and reservoirs also tend to reduce flow variability as flooding is reduced and the low-flow discharge becomes more constant. Such hydrologic changes reduce physical variability in the riverine ecosystem, which in turn reduces the diversity of the biological community.

2.6 SOUTHERN CALIFORNIA STREAM-RIVER SYSTEM

2.6.1 Geology and Soils

The coastal drainage area falls within two major geologic provinces in Southern California: The Transverse Ranges and the Peninsular Ranges, as shown in Figure 9. Also shown in this figure are the numerous active faults found within the Southern California drainage area, including the San Andreas fault. Rock types within the

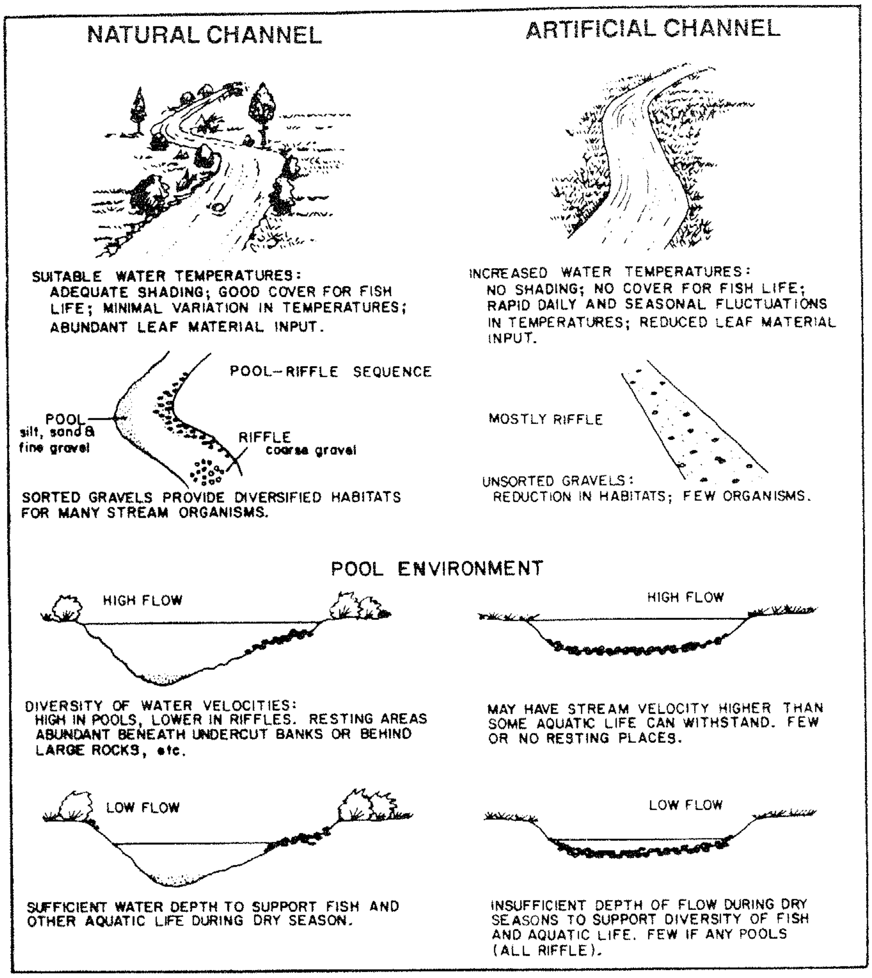


Figure 8. Comparison of a natural channel with an artificial channel (modified after Corning, 1975).

Transverse and Peninsular Ranges vary from young sedimentary rocks to older igneous and metamorphic rocks. However, in many instances the rocks are intensely sheared and altered by ongoing mountain-building. Rates of uplift and subsidence vary from less than 1 m a year to several millimeters a year, and horizontal motion along the San Andreas and related faults is several centimeters a year. The rate of uplift or horizontal motion along faults in the Southern California area is highly variable and site-specific, but the greatest rates of vertical uplift are in the western Transverse Ranges from the Ventura area south to Los Angeles. Lesser rates of uplift are found south of Los Angeles to San Diego. In the Transverse Ranges, rates of uplift are several times the rate of denudation, producing steep mountain topography that rises to elevations in excess of 3,000 m. Along the coast south of Los Angeles to San Diego, where rates of uplift are apparently less than in the Transverse Ranges, the topography is more subdued and often characterized by flat-topped mesas.

The geology, and particularly the active mountain-building, of Southern California has a tremendous impact on land forms, streams, and rivers of the area. Many streams and rivers flow along active faults for at least part of their length, and

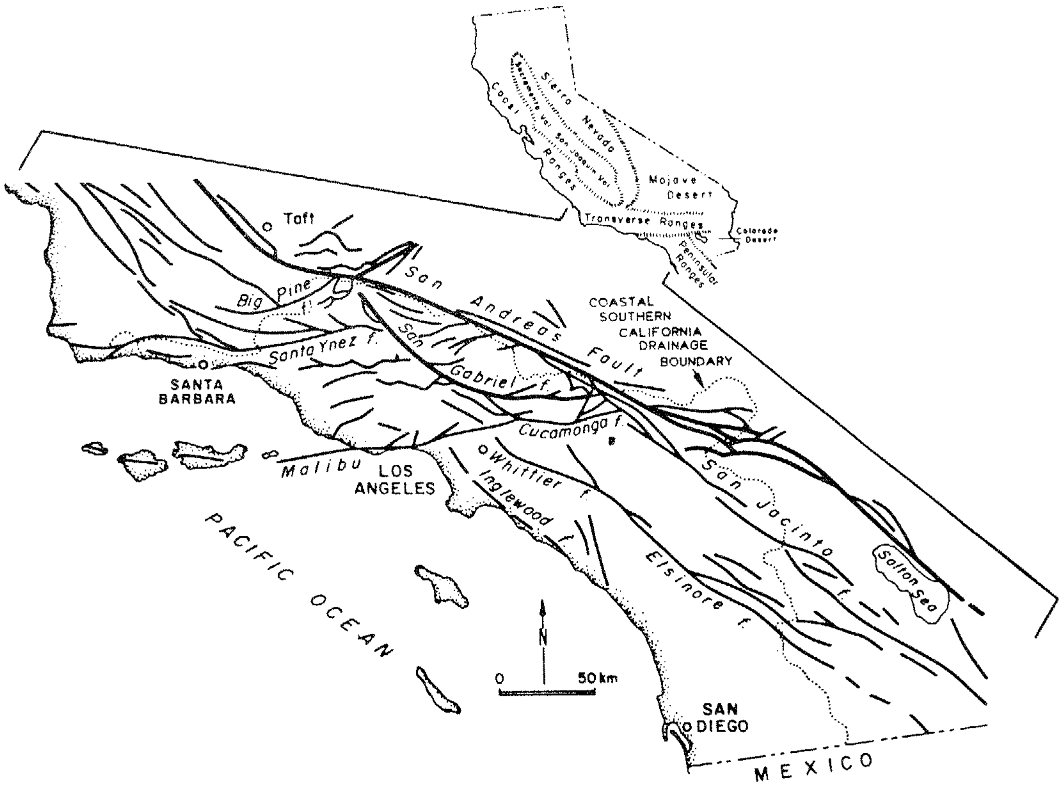


Figure 9. Generalized map of the Southern California drainage area showing the location of major active or recently active faults.

stream gradients, and thus sediment delivery and rate of runoff, are affected by geologic processes. In particular, the combination of weak crushed rocks and occasionally intense seasonal precipitation leads to periodic high rates of sediment production.

Soils in the Southern California drainage area are variable and dependent upon rock type, tectonic activity, topography, and climatic conditions, as well as time. In general, soils on floodplains and low river terraces are youthful and poorly developed, whereas better developed soils are found on older upland surfaces. Because rates of denudation are high in the Transverse Ranges where uplift rates are high, preservation of land forms and soils older than a few hundred thousand years is uncommon. On the other hand, in areas where uplift rates are low, residual soils on bedrock and soils on alluvial surfaces may be considerably older. Older soils are generally recognized by thicker profiles and "B" soil horizons with redder colors and higher clay content.

2.6.2 Climate, Hydrology, Sediment Production, and Fire

The climate of the Southern California drainage area is Mediterranean, characterized by periodic rainfall between the months of November and March. It is not unusual for most precipitation to fall in a few storms. During cool winter months, most precipitation results from unstable polar air masses that move into the area from the north Pacific. During fall and winter, tropical disturbances from the south occasionally produce intense precipitation; rainfall intensities of 2.6 cm in 1 minute, 29.2 cm in 2 hours, and

66.5 cm in 24 hours have been reported (Taylor, 1983). The summer months are mostly dry, with the exception of showers and thundershowers associated with tropical disturbances moving into the area from the south. Annual runoff and precipitation data shown in Figures 2 and 10 illustrate the extreme variability in both time and space. For example, while mean annual precipitation increases northward from San Diego (26 cm/yr) to Santa Barbara (46 cm/yr), local variability can be extreme. Figure 10 shows the rainfall record from 1870 to 1980 in terms of departure from averages. Twenty- to thirty-year wet and dry cycles are clearly delineated, but the pattern is far from consistent.

Increases in precipitation parallel increases in elevation of the headwaters of rivers. Most of the larger streams in Southern California that flow to the Pacific Ocean originate at sufficient elevations to receive at least 32 cm a year in precipitation, most of which falls during the winter months. As a result, under natural conditions the coastal drainage area is characterized by winter surplus and summer deficiency of water. Mean annual precipitation in headwater portions of Southern California drainage basins is 32 to 48 cm, 10 to 30 percent of which is converted to mean annual runoff (State of California, 1979).

As a result of the extreme variability in precipitation and runoff in the Southern California drainage area, the flow of water in streams and rivers tends to be extreme and associated with storms. Figure 11 shows some of the Southern California rivers (their locations are shown in Figure 2) in terms of the recurrence interval (RI) of flow and discharge measured as multiples of the mean annual flood. The recurrence interval refers to the statistical probability of a particular flow. For example, a recurrence interval of 10 years is the flow that is statistically expected to occur on the average of every 10 years and is designated the 10-year flood. The mean annual flood is a flood with a recurrence interval of 2.33 years and is close to the bankful event. Thus all

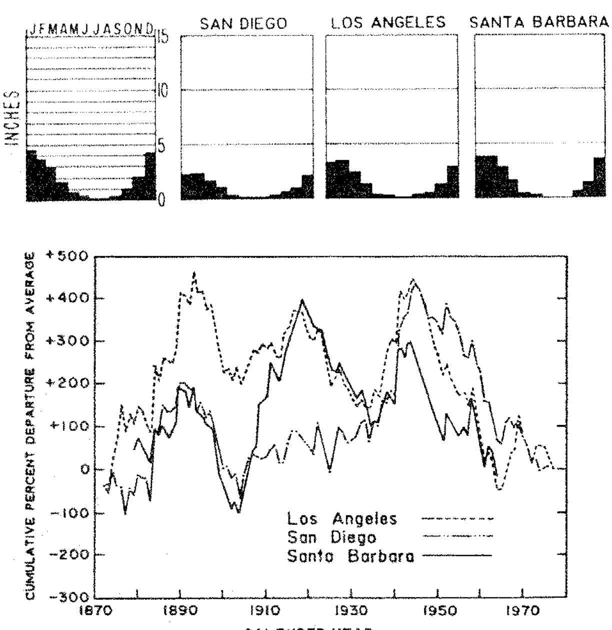


Figure 10. Mean annual precipitation in inches for San Diego, Los Angeles, and Santa Barbara, California (data from California Water Atlas, 1979).

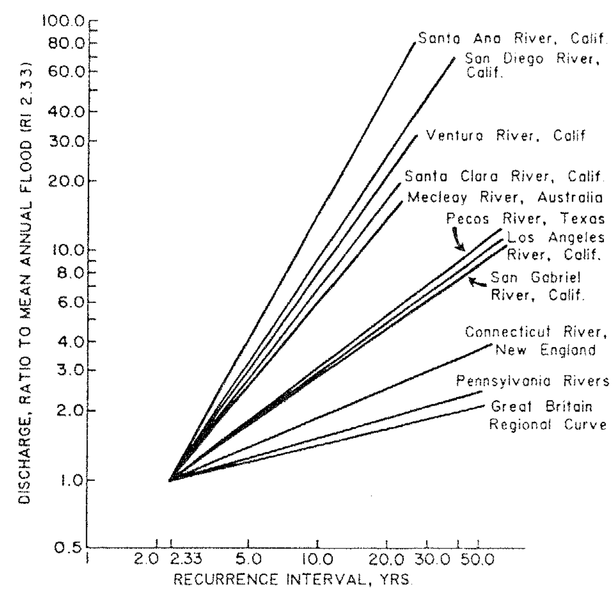


Figure 11. Relationship between mean annual flood and recurrence intervals for several rivers. See text for explanation.

rivers shown in Figure 11 start from a common recurrence interval of 2.33 years, which has a ratio to the mean annual flood of 1.

Figure 11 shows that rivers such as the Santa Ana, Ventura, and Santa Clara all have steeper slopes than is common in other parts of the United States and the world. The regional curve for Great Britain is the flattest, suggesting that floods with high-magnitude recurrence intervals of approximately 50 years are not much larger than the mean annual flood, whereas in the Santa Ana River, a flood with recurrence interval of 50 years would have a flow that exceeds by more than 100 times the mean annual flood. These data strongly support the contention that the variability of runoff and precipitation in Southern California can produce large floods.

Many streams in Southern California also have very low flow during the summer months and in many cases dry up in the lower and uppermost portions. However, streams that flow through rock canyons often have perennial flow because deep pools are fed by ground-water recharge. This pattern of low flow in summer, which may be distinctive to the Mediterranean climate, results in an interesting situation in which the headward parts of streams may be dry, the middle portion wet, and the low portion dry during the summer months. Southern Californians have known for years about this phenomenon, and many local rock canyons are refuge for residents who frequent those areas for swimming and fishing. In fact, many streams with these characteristics support good populations of trout and other aquatic life. In the northern streams these wet areas provide habitat for anadromous fish such as steelhead trout, which enter the streams during the winter to spawn. Young fish then return to the ocean during times of higher flow in subsequent years. The natural abundance of these anadromous fish is not well studied from Los Angeles to Point Conception in the Southern California coastal area.

Fish populations vary greatly from year to year, particularly in the lower reaches of smaller streams, but are not insignificant as is often assumed. For example, a small stream flowing through a housing area in the Goleta Valley had a good native population of rainbow trout during the winter of 1984. Fish from 15 to 40 cm in length were caught by several young fishermen.

Total sediment load from streams and rivers is generally measured in terms of suspended sediment, which is carried by the fluid flow in suspension, and bed load, which is carried along near the bottom of the channel. Table 1 summarizes suspended sediment yields for selected streams in Southern California, Northern California, and elsewhere in the United States. These data suggest that while suspended sediment yields in Southern California streams are high compared to other parts of the nation, they are not nearly as high as for Northern California rivers. Suspended sediment yields in Northern California are some of the largest found anywhere in the world because of the duration and intensity of precipitation falling on steep topography with highly erodable rocks and soils beneath that are easily exposed by landslides or timber harvesting. There is considerably less precipitation in southern than in northern parts of the state, so even though the topography is often steep and the rocks are susceptible to erosion in Southern California, yields of suspended sediment are not as high as those in Northern California.

Table 2 summarizes sediment yields from selected rivers in Southern California shown in Figure 2. The data are expressed in terms of the natural sediment yield prior to and following construction of dams and reservoirs. Also shown is the percentage of the drainage basin controlled by dams. These data suggest that the natural yield of suspended and bed-load sediment from a Southern California river is generally two to three times that following substantial control of the drainage basin. The data on sediment yield for the Los Angeles, San Gabriel, and Santa Ana Rivers are extremely limited, so the estimated yields are only approximations (Brownlie and Taylor, 1981).

The role of fire in the Southern California drainage area in increasing the yield of water and sediment, as well as disturbing stream and river ecosystems, is controversial and not well understood.

Table 1. Suspended sediment yields for selected rivers (data from Kelsey, 1977; Brownlie and Taylor, 1981).

Drainage basin	Drainage area (km^2)	Yield ($tons/km^2/yr$)
Southern California		
Ventura River	585	650[a]/1367[b]
Santa Clara River	4,219	749[a]/836[b]
San Diego River	1,119	131[a]/267[b]
Northern California		
Eel River	7,778	3,892
Van Duzen River	570	3,409
Redwood Creek	720	3,089
Other in U.S.A.		
Schuylkill River, Pa.	4,902	202
Delaware River, N.J.	17,560	57
Rio Grande River, N.M.	67,153	136
Mississippi River, La.	3,220,665	94

[a]Controlled.
[b]Natural.

Some studies have suggested that after a fire, sediment yields increase only about 10 percent; other studies have shown that sediment yields may be increased many times. Certainly the effects are most pronounced in the first few years immediately following a fire, particularly if they are wet years, and impacts decrease as vegetation becomes reestablished. Fire is a frequent occurrence, particularly in the upland drainage basins throughout Southern California, and study of its effects, particularly on riparian vegetation and aquatic communities, should be expanded.

Possible effects of fire on sediment production are illustrated in Figure 12, which shows the change in sediment storage in Gibraltar Lake, Santa Barbara's primary reservoir, from 1920 to 1980. The graph suggests that if the height of the dam had not been raised in 1949, the lake would now be completely filled with sediment. Fire occurrences are shown on the graph. Steep portions of the curve reflect times when sediment was being delivered at an accelerated rate and are closely correlated to fires in the drainage basin. For example, the 1964 Coyote Creek fire, which burned 40,000 acres (16,188 ha) in the Gibraltar watershed, was associated with loss of 4,521 acre-feet (5.57×10^6 m^3) of storage in Gibraltar Lake over the five-year period immediately following the burn. The fire affected 28.5 percent of the Gibraltar watershed, and the data suggest that a similar fire might fill the reservoir with sediment, producing a loss of water supply to the city of Santa Barbara.

2.6.3 Channel Disturbance

It is difficult to assess the impact of human use on the streams and rivers of Southern California because of the large number of potential disturbances, including channelization, construction of dams and reservoirs, mining of the streambed for sand and gravel, land-use changes, and recreational use. A quantitative assessment of the overall impact on the Southern California drainage area is beyond the scope of this chapter. However, to approximate the effects of human use and interest on the riparian environment, a preliminary inventory has been made of channel condition and adjacent land use along the main channels and major tributaries of seven drainage systems in Southern California: Ventura, Santa Clara,

Table 2. Sediment yield for seven selected rivers in Southern California (data mostly from Brownlie and Taylor, 1981).

Drainage basin	Drainage area (km^2)	% of drainage basin controlled by dams	Annual suspended sediment yield ($tons/km^2$)		Annual bed load yield ($tons/km^2$)	
			Natural	With dams	Natural	With dams
Ventura	585	42	1,367	650	489	231
Santa Clara	4,219	37	836	749	254	227
Los Angeles	2,155	40	Estimated for Los Angeles and San Gabriel combined		Estimated for Los Angeles and San Gabriel combined	
San Gabriel	1,663	84	748	249	267	89
Santa Ana	4,406	90	448 estimated	151	160 estimated	54
San Luis Rey	1,450	37	132	42	46	15
San Diego	119	61	267	131	94	46

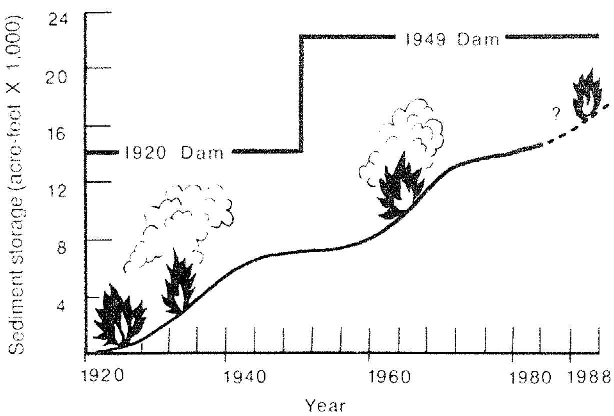


Figure 12. Loss of reservoir storage in Gibraltar Lake from 1920-1980 (data from City of Santa Barbara, 1981).

Los Angeles, San Gabriel, Santa Ana, San Luis Rey, and San Diego Rivers. In all, over 2,000 km of stream channels were inventoried from aerial photography (scale 1:130,000) with a limited field check. Data from this survey are shown on Table 3.

The river systems studied differ considerably in channel condition and adjacent land use. For example, 82 percent of the channel in the Los Angeles River basin is lined with concrete, compared with only 2 percent or less in the Ventura, San Luis Rey, and San Diego Rivers. Probably the most encouraging aspect of the data is that along the Ventura, Santa Clara, San Gabriel, Santa Ana, San Luis Rey, and San Diego Rivers there is still an appreciable amount of riverbed and banks that are natural in appearance and some have a significant amount of riparian vegetation. This suggests that in some areas there remains a potential for conservation or enhancement of riparian habitat for fish and wildlife.

2.7 SUMMARY

Of the total drainage area of Southern California, 53 percent, more than 32,000 km^2, is controlled by dams and reservoirs.

Table 3. Channel conditions and adjacent land use for selected rivers in Southern California. Data from 1:130,000 scale aerial photographs (1979 or 1983) collected by Cindy Hovind with supervision by the author.

Characteristic	Ventura	Santa Clara	Los Angeles	San Gabriel	Santa Ana	San Luis Rey	San Diego
Length of rivers observed (km)[a]	144	515	378	170	448	227	227
Channel conditions							
Natural	70%	59%	12%	42%	36%	60%	69%
Straightened[b]	27%	35%	6%	4%	35%	39%	30%
Concrete lined[c]	2%	6%	83%	55%	29%	0%	1%
Riparian vegetation[d]	100%	60%	17%	47%	46%	100%	96%
Land use adjacent to channel[e]							
Natural	55%	67%	14%	45%	44%	65%	68%
Urban	22%	16%	85%	55%	40%	9%	34%
Agriculture	24%	26%	1%	0%	19%	28%	4%

[a]Total length of main channel and major tributaries inventoried.
[b]Altered but not concrete-lined.
[c]Channels with concrete banks with or without a concrete bed.
[d]Trees, bushes, and brush within or on the banks of river channels, whether native or introduced.
[e]Percentages do not total 100% because of different land uses on opposite sides of channel.

The stream or river channel and adjacent floodplain are characterized by processes of erosion, transport, and deposition. Hydrologic and morphological changes in streams and rivers occur in response to thresholds that are exceeded, and often these changes take place abruptly. Channelization projects reduce the hydrologic and physical variability of streams and rivers, and thus the diversity of biological communities as well. Because of the extreme variability in precipitation and runoff, flows of water in streams and rivers tend to be extreme with large flows as flash floods related to storms. Suspended sediment yields are high, though not as high as in Northern California, and are often associated with fire.

CHAPTER 3. THE RIPARIAN COMMUNITY: PLANTS

3.1 HISTORY OF RIPARIAN FORESTS OF SOUTHERN CALIFORNIA

According to Axelrod (Robichaux, 1977), who has considered the evidence from numerous fossil floras now known in the western United States, modern plant communities of California are composed of assemblages of taxa derived from diverse floristic sources. Axelrod (1950, 1967) has examined species composition (individual lineages and communities) in the context of former topographic, climatic, and vegetational settings, concluding that in today's riparian community of Southern California there are representatives from both a southern madro-tertiary xeric element and from a northern arcto-tertiary mesic element. The southern element includes *Arbutus*, *Arctostaphylos*, *Ceanothus*, *Cercocarpus*, *Cupressus*, *Quercus*, and *Umbellularia*, whereas the northern element includes species in such genera as *Acer*, *Alnus*, *Castanopsis*, *Fraxinus*, *Picea*, *Quercus*, and *Sequoia*. Modern communities are impoverished representatives of richer, more generalized ancestral communities. Taxa were gradually eliminated from California during the late Tertiary period in response to a general trend toward a cooler, drier climate and a shift in the seasonal distribution of precipitation. Some of the species in the modern riparian community are associated, as ancestral forms, in fossil communities throughout most of California's late Tertiary and Quaternary history, covering a time span of 20 million years.

Robichaux (1977) compared present and past distributions of some dominant woody species in the riparian community (Table 4). One example is provided in Figure 13. As the climate became cooler and drier with more distinct seasons, certain species, such as boxelder (*Acer negundo* var. *californicus*) and valley oak (*Quercus lobata*), were eliminated from the northern part of their ranges and became restricted to California. Other species, such as yellow willow (*Salix lasiandra*), remained in the north but gradually were confined to the mild coastal strip where the effects of changing climate were smallest. Still other species, such as white alder (*Alnus rhombifolia*), apparently were able to survive in unmodified form in the northern interior regions. Robichaux speculates that when an association of species in a fossil flora resembles those in a modern community, the community was formed in the ancient landscape with habitat requirements similar to those of its modern counterpart.

3.2 THE RIPARIAN COMMUNITY

3.2.1 Water Regime

Riparian vegetation is directly related to the physiography and hydrology of stream systems, including factors relating to watershed dimension (size, elevation, slope exposure, stream gradient, etc.). Where slopes are steep, swift water scours the streambed down to bedrock. Major storms tear out large stands of vegetation and frequently alter stream courses. Where gradients are shallow, alluvium is deposited, providing sites for plants to become established. General floristic patterns in riparian habitat remain in a perpetual state of succession, following changes in land forms and water regimes.

a. Perennial streams form in the higher mountain ranges from springs, coalesce into large streams, and finally flow out of the mountains onto the floodplain as sizable rivers. Above 7,000 ft, associated riparian vegetation consists almost entirely of shrubby montane species of

Table 4. Some common species in the modern riparian forest of Southern California and their counterparts in the late Tertiary fossil record of the Western United States (adapted from Robichaux, 1977).

Modern species[a]	Fossil species[b]
Acer negundo	A. minor
Alnus rhombifolia	A. hollandiana, A. merriami
Cornus californica	C. ovalis
Fraxinus latifolia	F. coulteri, F. caudata
Juglans californica	J. pseudomorpha
Platanus racemosa	P. paucidentata
Populus fremontii	P. prefremontii
Quercus lobata	Q. prelobata, Q. moragensis
Salix lasiandra	S. hesperia
Salix lasiolepsis	S. wildcatensis
Salix laevigata	S. laevigatoides
Salix gooddingii	S. truckeana
Salix hindsiana	S. endenensis
Toxicodendron diversilobum	T. franciscan

[a]Nomenclature follows Munz, 1959.
[b]Leaf and seed impressions of the fossil species are generally indistinguishable from those of their modern counterparts. A different name is assigned to the fossil taxon to avoid the difficulties of equating modern and fossil species.

willow (Salix spp.). Jeffrey pine (Pinus jeffreyi) and incense cedar (Calocedrus decurrens) often grow near the edges of streams (Figure 14). Below 7,000 ft, white alder and willow commonly occur along seasonally flooded streambanks between low-water and maximum flood levels, often in dense stands of young trees (Figure 15). Cottonwood (Populus spp.) and sometimes sycamore (Platanus racemosa) grow in the seasonally flooded habitat but more commonly on banks, crests of banks, and terraces along the stream above the zone of seasonal inundation but in an area where the water table remains close to the surface and where roots are probably in saturated soil (Ferren, 1984). Sycamore, coast live oak (Quercus agrifolia), and California bay (Umbellularia californica) grow to very large sizes on first, second, and third terraces above the streambed. Here, where sufficient light penetrates for shrub and herb development, can be found the richest assemblages of understory riparian species, including mule fat (Baccharis glutinosa), dogwood (Cornus spp.), elderberry (Sambucus mexicana), and wild grape (Vitis girdiana). In areas where there is a well-developed canopy, perennial water flow, and rocky or cobbly substrate, only scattered, nonpersistent vegetation grows (Ferren, 1983). Understory plant diversity increases significantly near low-energy portions of the stream, particularly where silt accumulates and there is greater sunlight penetration between older and taller trees.

b. Hybrid streams, characterized by perennial or year-round aboveground flows in some years and intermittent flows in others, often form in mountains at lower elevations or on smaller watersheds. In these streams alder drops out; willow, cottonwood, sycamore, and coast live oak remain as dominant species, the latter two often attaining large sizes from subsurface water supplies.

c. Intermittent streams flow for at least part of the year aboveground. In

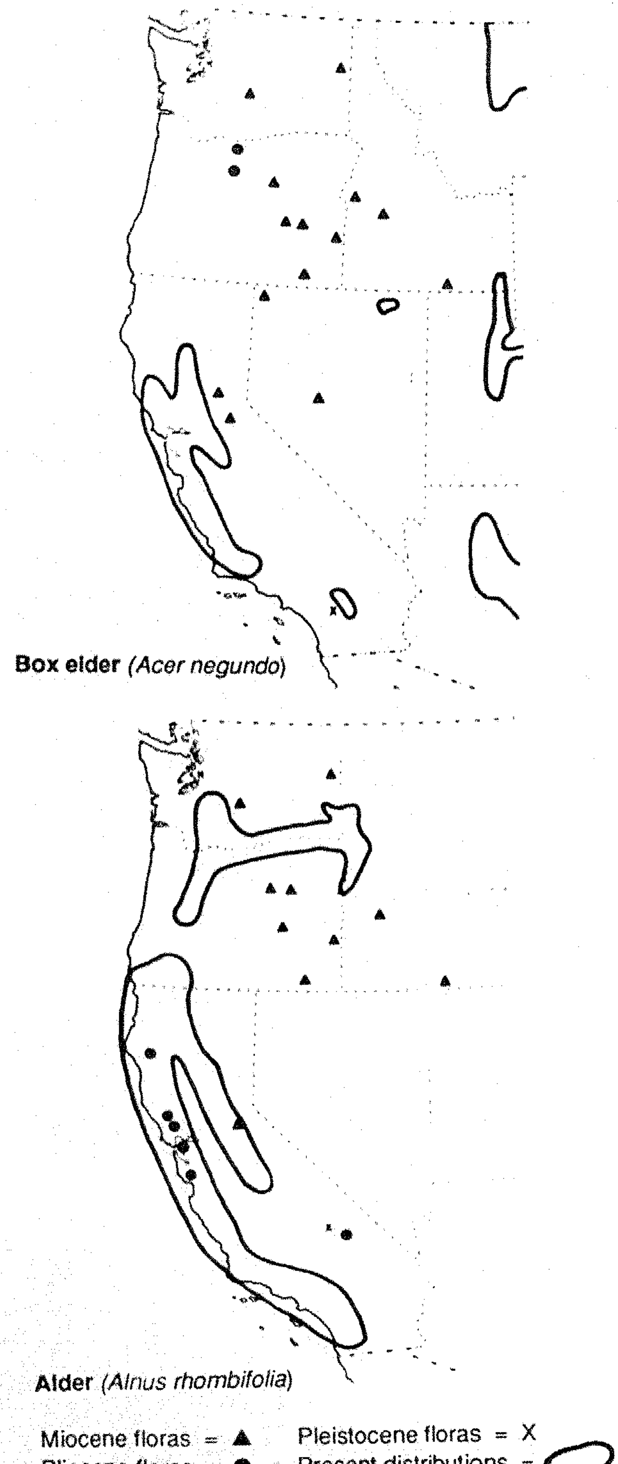


Figure 13. Past and present geographical distributions of box elder and alder (from Robichaux, 1977).

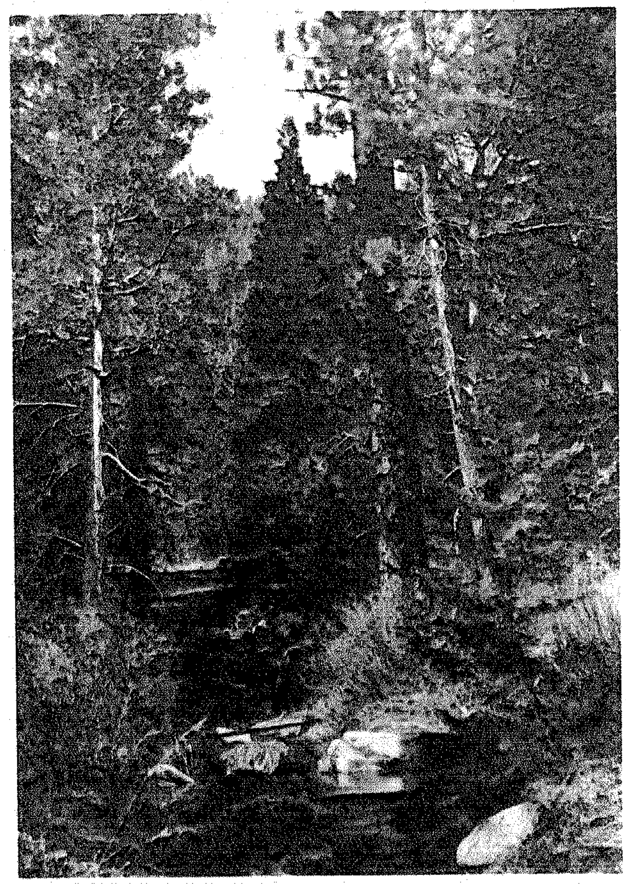


Figure 14. Pine and incense cedar grow near the edge of Mill Creek at 5,900 ft in the San Bernardino Mountains.

these streambeds soils are kept moist, not saturated, by winter rains and subsurface water levels and are often sheltered by north-facing slopes or adjoining bluffs to the south, and willow and cottonwood drop out. Typically, sycamore moves down into the streambed, along with coast live oak and California bay, sustained by subsurface water sources (Ferren, 1983).

The diversity of emergent herbaceous plants increases significantly in intermittent streams with exposed sand and gravel substrates that receive direct sunlight through an open or non-existent riparian canopy (Ferren, 1983).

d. Ephemeral streams flow in years of heavy rainfall, particularly during large storms. Coast live oak, typically of smaller stature, remains the dominant

Figure 15. Wheeler Gorge Campground on Sespe Creek. Alder, the most reliable riparian indicator species, grows along seasonally flooded streambanks between low-water and maximum flood levels.

species in a habitat with less certain and less abundant water supply. This habitat often appears as a continuum or ecotone with vegetation on north-facing slopes, as can be seen in the Santa Monica Mountains where California walnut (Juglans californica) grows in streambeds and up onto north-facing slopes.

e. Floodplains and alluvial fans of a number of watercourses flowing out of the San Gabriel, San Bernardino, and San Jacinto Mountains support a distinctive plant community, structurally and floristically diverse, consisting of an unusually large proportion of arborescent evergreen shrubs and a rich assemblage of subshrubs, as shown in Figure 16 (Smith, 1980).

3.2.2 Community Structure

Structure and composition of riparian forests are directly related to factors such as water regime, frequency of disturbance, air temperature, root-zone aeration, depth of ground water, width and elevation of the floodplain, and the stand age of trees. The community can be divided into three zones: an active zone closest to the stream that is most subject to disturbance from winter storm damage and is characterized by willow and alder; a border zone that is less subject to disruption but has a reliable water supply and is characterized by larger trees of willow, cottonwood, sycamore, and a well developed understory with considerable plant diversity; and an outer zone on higher terraces

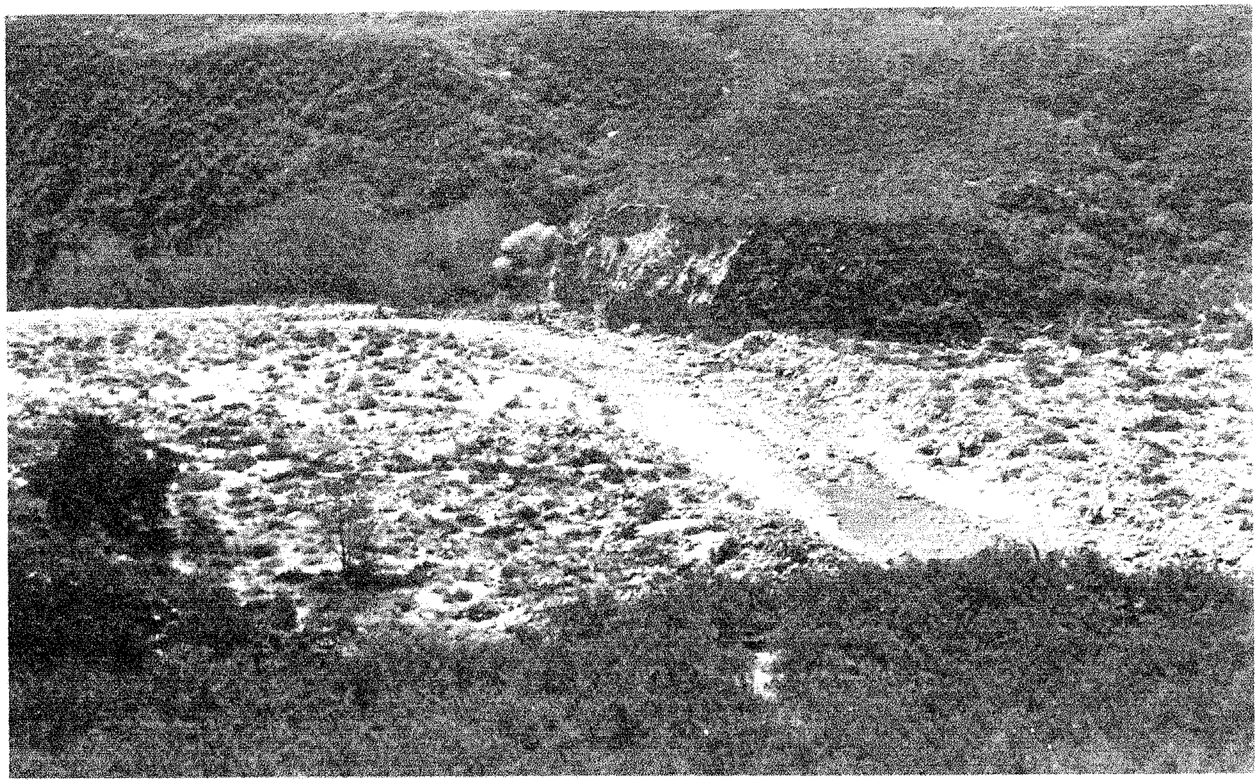


Figure 16. View of an alluvial fan plant community, a distinctive community of shrubs and subshrubs that once covered much of the Los Angeles Basin. This remnant is along the San Jacinto River at 2,500 ft.

that are only occasionally subjected to flooding but where trees, particularly sycamores and oaks, take advantage of the higher water tables found adjacent to rivers and streams and grow to very large sizes.

Availability of water, frequently in combination with deep soils, increases plant biomass production and provides a suitable site for plants that are limited in adjacent upland communities by inadequate water and shallow soils (Minore, 1970). Riparian communities, particularly in the border zone, often exhibit considerable diversity in plant species. This is especially true for those adapted to wet or moist conditions (Maximov, 1931; Campbell and Green, 1968; Hortone, 1972). These plants generally are characterized by large, soft leaves; examples are wild grape and elderberry. Little emphasis has been placed on the understory in this community profile, but it should be pointed out that it plays a major role in the riparian community. Many fauna, birds, and insects are closely associated with and dependent on the dense, lush foliage and its associated microclimate.

Riparian zones usually have a high rate of recovery and develop a range of successional vegetation where the habitat is protected or appropriately managed. From information on riparian forests of the Sacramento River that is pertinent to the riparian forests of Southern California, Strahan (1981) observed that cottonwood and willow are the classic pioneer species of riparian forests. Seeds of both species initially become established almost exclusively on recently deposited exposed alluvium. These trees predominate in young stands on low terraces near the river.

More mesic species, such as boxelder and black walnut, enter cottonwood/willow stands over time and predominate in stands away from the river. Oak and sycamore are found in old stands on high terraces and along banks high above the river. Species diversity increases as stands age, reaches a maximum in stands with mixtures of pioneer and later successional species, and may decline slightly in oldest stands (Figure 17).

It has been shown that when disturbance is high, willow dominance shifts to sandbar willow (Salix hindsiana) and, when somewhat less severe, to Goodding's willow (Salix goodingii). Cool growing seasons favor black cottonwood, whereas turbulent, well-aerated water close to the surface allows white alder to become dominant. When water tables are deep, sycamore is the usual dominant species where aeration of the soil is high, and valley oak is dominant where aeration is low (Holstein, 1981).

From a study of four coastal streams in Santa Barbara County, Ferren (1983) reported that white alder and willow usually grow in seasonally flooded habitats between low water and seasonal maximum flood levels as determined by a line of debris along the streambank. Sycamore, black cottonwood, coast live oak, toyon (Heteromeles arbutifolia), California bay, laurel sumac (Rhus laurina), and elderberry usually grow on banks, crests of banks, and terraces along streams above the zone of seasonal inundation, where the water table remains close to the surface and where the roots are probably in saturated soil. The latter three species also continue up the ravine slopes and are found in southern coastal oak woodland or coast live oak forest communities. As a part of the riparian community, they are not dependent on the additional water source, but are tolerant of occasional flooding and saturated soils.

In a study of plant distribution gradients from streamside riparian to adjoining upland habitats on the west fork of the San Gabriel River, Brothers (in press) found that of the vegetation in a riparian zone, a few species were riparian and a much larger number were from adjacent

Figure 17. Tapia County Park near Malibu. Willows are pioneer plants that predominate on low terraces near the stream, while cottonwood and sycamore predominate on higher terraces.

nonriparian areas integrading into the riparian zone. He found considerable variation in species composition between north- and south-facing slopes and between small and larger basins, indicating the importance of moisture availability. Syvertsen (1974) studied moisture stress (stem water potential) in coast live oak during a dry year and found it to vary with slope position. All species studied showed lower stress at the bottom of the slope. Stand density influences moisture stress where total water supply is limited, so that stands with widely spaced trees suffer less moisture stress in dry seasons than do trees in dense stands (Rundel, 1980). California walnut and toyon both had lower stress in open south-facing plots than in the denser north-slope stands (Syvertsen, 1974).

3.2.3 Deciduousness and Productivity

The presence of winter-deciduous vegetation in the riparian communities of California is an anomaly in a state known for its Mediterranean-type climate and sclerophyllous evergreen vegetation (Holstein, 1981). Deciduousness is promoted whenever a long, productive growing season is paired with minimally productive but not necessarily stressful cool or cold season. Trees with rich stores of food can afford the energy cost of producing a new crop of leaves each year. The productivity potential in California, frequently unfulfilled because of summer drought, is realized in the riparian vegetation that lines perennial streams. These streams carry the part of the winter water surplus that is slowly released from deep aquifers and melting mountain snow, making it available to lowland riparian vegetation in summer when little water is available from local climate. The greater productivity and biomass of this vegetation is particularly obvious when contrasted with that of nearby communities that lack imported water (Holstein, 1981).

3.2.4 Regeneration

Riparian systems serve as seed sources for downstream ecosystems. Seeds are transported within the riparian system from one point in a stream to a downstream location or are carried into the riparian system from adjacent ecosystems by winter runoff and are deposited by flood waters.

Seasonal variation of flow regimes greatly influences establishment and survival of pioneer species, cottonwood and willow, on gravel bars. According to Strahan (1981), establishment and survival of riparian species are related not only to the physical characteristics of landforms but to a sequence of fluvial events. During the winter, streamflows must remove humus and freshly fallen leaf litter from the surface so seeds land on mineral soil. A receding water level in late spring and early summer must coincide with cottonwood and willow seed dispersal. Willows are more commonly found on finer textured deposits, while cottonwoods develop on the more coarsely textured deposits. Cottonwood seeds require a moist surface for germination. Fresh seeds germinate more rapidly than old seeds and, in studies in Arizona, Fremont cottonwood seeds remained viable for only five weeks under natural conditions (Fenner et al., 1984).

Rapid root growth rates are essential for cottonwood seedlings because the moist alluvium deposited in the spring dries rapidly with the onset of high summer temperatures. The declining water table also promotes root growth to greater depths. Before further flooding, seedlings must achieve sufficient size to withstand mechanical injury. The subsurface of bars must remain moist throughout the summer in order for seedlings to withstand late summer drought. While initial seedling density is usually very high, winter floods and summer drought account for significant seedling mortality (McBridge and Strahan, 1984).

Within the mature riparian forest the link between regeneration and flow regime is not as direct. Floods may remove or bury in silt seedlings established for one or more seasons. Boxelder, black walnut, and oak seeds all germinate through litter and under the shade of established cottonwood and willow forests (Strahan, 1981).

3.2.5 Succession

Riparian plant communities undergo a natural and predictable sequence of revegetation after destruction by flooding. Such succession may take 50 to 75 or more years to complete, starting from bare sand and culminating in a mature riparian forest or woodland community on the floodplain extending varying distances from the stream channel, depending on land contours (Smith, 1979). In contrast to the mature forest or woodland farthest from the watercourse, which requires years to mature, immature expressions of the riparian community develop rapidly, forming gravel-bar thickets and open flood-plain vegetation. Often this active zone will consist solely of widely scattered herbs or of immature willow (Figure 18). According to Smith (1979), those mixed stands of willow and cottonwood that typically develop on middle terraces of streams may be the oldest stands of trees along the Santa Clara River. These areas are not subject to flooding and erosion as often as lower levels, and thus the vegetation can achieve a more advanced stage of succession than on floodplains and gravel bars. Large sycamore and cottonwood, found on middle terraces, and oak trees, found on the upper terraces of floodplains and in canyons, are rarely subjected to floods and grow to very large sizes (Phillips, 1963); however, too often many are cut down to provide agricultural lands. It is the middle and outer zones of the riparian community that are the most depleted.

3.2.6 Tolerance of Flooding

Teskey and Hinkely (1980) and Walters et al. (1980) have reviewed the literature on long- and short-term responses of plants to

Figure 18. Thickets of mulefat become established between floods on gravel bars as seen along Piru Creek at 1,600 ft elevation.

flooding. The major effect of flooding or of saturated soils is to create an anaerobic environment surrounding the root system as water replaces air spaces in the substrate. The anaerobic environment (oxygen/CO_2 levels and ion-exchange reactions) interferes with normal root metabolism, resulting in plant stresses that affect physiological activities such as water and nutrient uptake, xylem and phloem transport, photosynthesis, and transpiration. A root system formed under aerobic conditions becomes dormant or begins to die immediately after flooding. A plant's tolerance of lengthy periods of flooding is dictated by its ability to grow adventitious roots and new secondary roots under low-oxygen conditions. A flood-tolerant species can maintain a root system developed under aerobic conditions in a partially anaerobic rhizosphere while producing new secondary or adventitious roots. Intolerant species not only suffer normal root system loss but are unable to produce adventitious roots (Hosner, 1958, 1960).

Sycamore, cottonwood, and willow are all considered flood-tolerant, whereas big-leaf maple, California bay, and coast live oak are all considered intermediately tolerant, that is, able to withstand 1 to 3 months of flooding during the growing season (Harris et al., 1979). Alternating periods of watershed runoff, resulting in flooding of the riparian ecosystem, followed by periods of summer drought, appear to be essential for preserving the diversity of riparian vegetation (Onuf, 1983).

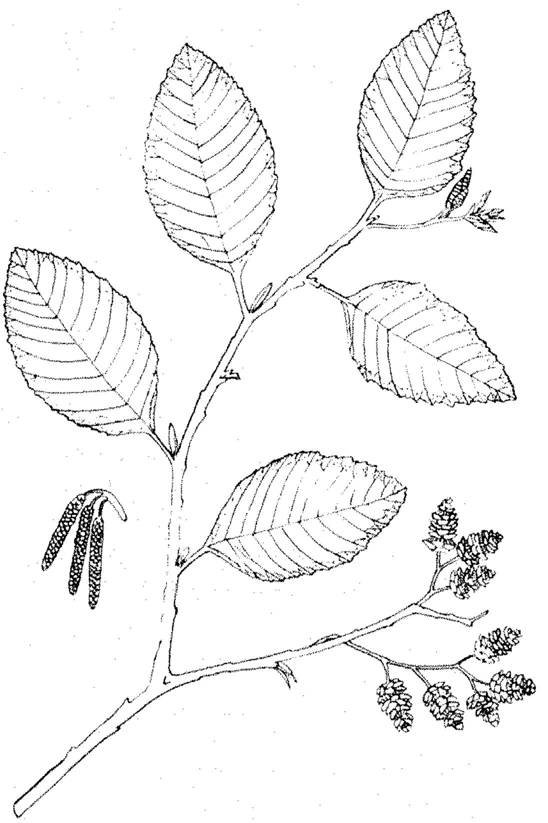


Figure 19. White alder (Alnus rhombifolia). Drawing by W. Bailey.

3.3 COMMON PLANTS IN SOUTHERN CALIFORNIA'S RIPARIAN COMMUNITY

White alder (Alnus rhombifolia), ranging from Southern California north to British Columbia, is a riparian deciduous tree (Figure 19). In coastal or cismontane Southern California, it is restricted to permanent streams and thus is a more reliable indicator of the presence of water than either sycamore or cottonwood (Jepson, 1923). At 6,500 ft and below, alder forms dense groves at the heads of mountain streams and intergrades with cottonwood and willow at lower elevations. It descends to the mouths of canyons only where cold air and abundant water permit, as, for example, on the Mentone fork of the Santa Ana River (T.L. Hanes, California State University, Fullerton; pers. comm.). Alder is an early pioneer following major storm scouring, which significantly alters streambeds, and reestablishes quickly by vegetative growth from existing root systems and by seed. Trees grow rapidly, showing a maximum growth in diameter of 3.84 cm a year (Long, 1982). White alder grows from 30 to 100 ft tall, with a thin, open crown and a straight, slender trunk 1-3.5 ft in diameter. Trees are monoecious, producing male and female catkins on a single tree and seeds in cone-like structures that form in greater abundance in full sunlight than in partial shade. Reproductive success is best in moist or wet sand, gravel, or humus soil, where seedlings grow rapidly and form open stands on stream borders (Sudworth, 1967). The ecological factor that most controls the distribution of white alder seems to be the need for consistent saturation of its root zone by cool, well-aerated water.

Willows (Salix spp.) are fast-growing deciduous trees that are faithful indicators of riparian habitat. The genus name is derived from the Celtic sal, near, and lis, water, in reference to its place of growth, or from the Latin word for willow. Willows spread vegetatively from root sprouts into large stands, often forming the dominant overstory, usually with a deep litter layer or herbaceous understory. Trees are of one sex only, and a stand will often be all male or all female, with female stands usually outnumbering male stands. Flowers are both insect- and wind-pollinated and develop in catkins from which numerous seeds, winged with silky down, are produced and dispersed by wind.

Red willow (Salix laevigata) grows at elevations up to 4,000 ft, often with yellow willow, along fast-flowing perennial streams in cismontane Southern California and on Catalina Island. Trees are of medium size, 20-40 ft tall, and can be recognized by their dark, rough trunk bark and reddish bark on young branchlets (McMinn and Maino, 1967).

Yellow willow (Salix lasiandra) extends into cismontane Southern California to elevations of 8,000 ft and onto Santa Cruz Island, where it grows along streambanks and in perennially wet places. While there is considerable habitat overlap between yellow and red willow, the former may have less tolerance for habitats along intermittent streams than red willow and thus need more permanent water. According to G. Holstein (University of California, Davis; pers. comm.), this observation needs verification. At lower elevations, yellow willow grows into medium-sized trees 15-45 ft tall and at higher elevations into shrub-like forms. It is easily recognized by the yellow color of its 1-year-old branchlets, its glandular-warty petioles, and its long, tapering leaves.

Goodding's willow (Salix gooddingii var. variabilis) is found along streambanks and in wet places in drier habitat areas in cismontane Southern California to elevations of 1,500 ft, where it grows into trees 20-60 ft tall. Its distribution, limited to the riparian zones of the Central Valley, Southern California, and the deserts of the Southwest suggests a need for a long, hot growing season and abundant ground water (Holstein, 1984) (Figure 20).

Arroyo willow (Salix lasiolepis) is also called white willow because of the smooth, ash-gray bark of young trees and branches of older trees. It is widely distributed in cismontane Southern California. Along perennial streams at low elevations, down to 100 ft, it grows into small trees 15-25 ft tall. At elevations up to 2,500 ft and along intermittent watercourses where there are moist benches, depressions, and gentle slopes with damp humus and rocky or gravelly soil, it assumes a spreading, shrubby form. In addition to its ash-gray bark, arroyo willow can be identified by its leaves, which are dark yellow-green and glabrous on the upper surface and exchange

Figure 20. Goodding's willow (Salix gooddingii). Drawing by W. Bailey.

reactions, interferes with normal silvery, often silky, in appearance on the lower surface (Figure 21).

Sandbar willow (Salix hindsiana) is very common along sandbars and riverbeds, particularly near the coast, but it is found up to 3,000 ft in cismontane California. Sandbar willow grows as a tree, up to 20 ft tall, or as a shrub; it can be distinguished by its gray, furrowed bark and gray, silky-haired leaves with exceptionally short petioles (Peattie, 1953).

Fremont cottonwood (Populus fremontii) is scattered throughout Southern California along streams and on lowlands between the mountains and the sea. Disjunct populations grow on Santa Cruz and Santa Catalina islands (Griffin and Critchfield, 1976). Fremont cottonwood is confined to alluvial stream bottoms and their borders in moist, sandy, and humusy soils or moist, gravelly ones, rarely growing in dry foothills except along perennial streams. Growing from 50 to 100 ft tall, with a diameter of 1.5-4 ft, this tree will occasionally become established along intermittent streams where it rarely survives to a mature age (Peattie, 1953).

Fremont cottonwood (Figure 22) is a short-lived, fast-growing, deciduous tree that grows in strips along streambanks, in small pure stands, or scattered in mixtures of willow. It occasionally grows with California sycamore and, at higher elevations, with white alder. It revegetates from root shoots or by seed. Flowers appear before leaves in the spring, are pollinated by wind, and grow in long catkins with the sexes on separate trees. Innumerable minute, short-lived, cottony

Figure 21. Arroyo willow (Salix lasiolepsis). Drawing by W. Bailey.

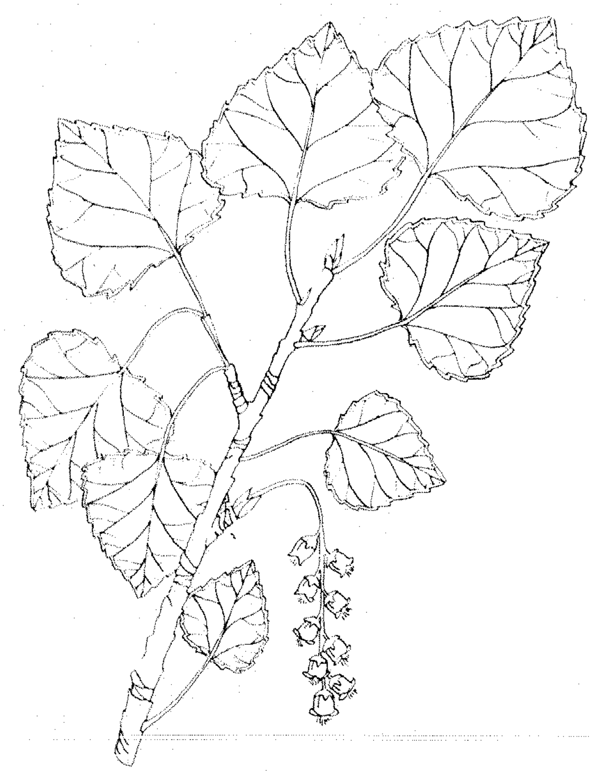


Figure 22. Fremont cottonwood (Populus fremontii). Drawing by W. Bailey.

seeds are effectively disseminated by wind. These have a high rate of germination, but a transient vitality (Fenner, 1984; Sudworth, 1967).

Black cottonwood (Populus trichocarpa) grows at higher elevations than Fremont cottonwood and along the coast. In cismontane Southern California the ranges generally overlap. There are disjunct populations on Santa Cruz, Santa Catalina, and Santa Rosa Islands (Sudworth, 1967; Griffin and Critchfield, 1976). Beyond elevational distribution, the two species differ in size and in leaf shape and color. Black cottonwood is the tallest species of poplar, growing 80-125 ft high at lower elevations and smaller at higher elevations, where it grows with white alder, incense cedar, and occasionally big-cone Douglas fir. Seedlings survive well on moist, bare humus or sandy soils and are often abundant on wet gravel bars.

California sycamore (Platanus racemosa) is abundant at elevations below 4,000 ft throughout cismontane Southern California along streams and near springs, on alluvial benches or in moist gullies where water from streams or ground-water supplies are either perennial or intermittent (Sudworth, 1967). Every likely canyon and creek bottom has sycamore trees (Figure 23). They grow in small groups in pure stands or mixed with white alder, big-leaf maple, California walnut, and occasionally willow, with a coastal sage-scrub or herbaceous understory. When growing close to a stream where soils regularly shift from periodic flooding, sycamores may exhibit extensive leaning, sprawling, or fork-shaped growth. Trees growing farther from the streambank grow upright, 40-90 ft tall, with thick, barrel-shaped trunks supporting massive crowns of wide-spreading limbs. California sycamore is a tenacious tree, repeatedly repairing damage to its crown and limbs by vigorous sprouts and growth of wood. It is a deciduous tree with broad leaves, 5-11 inches long and wide, for which the genus is named (the Greek word platys means broad). It has tiny unisexual wind-pollinated flowers borne in ball-like clusters on the same tree. The large, bristly, globular fruit breaks up at maturity, releasing the numerous small nutlets that are disseminated by drifting on the wind in fall. One of the largest

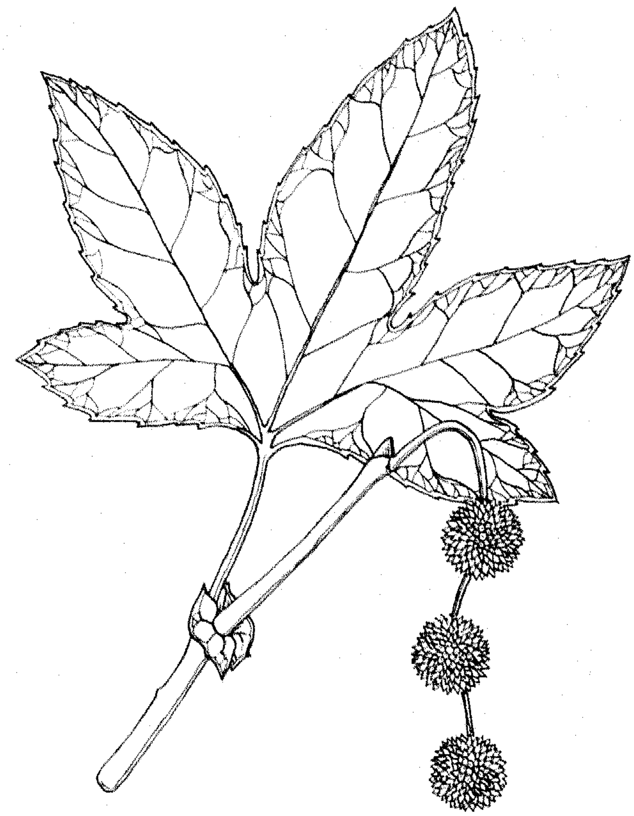


Figure 23. California sycamore (Platanus racemosa). Drawing by W. Bailey.

sycamores still stands on Milpas Street in Santa Barbara, a quarter mile from the beach. A lantern was once hung in the upper branches on stormy nights to guide boats along the coast before the harbor was built (Peattie, 1953).

Boxelder (Acer negundo var. californicum), another deciduous riparian tree, is limited in coastal Southern California to the Santa Ynez Mountains in Santa Barbara County, below Fort Tejon and Canada de las Uvas in the Tehachapi Mountains, and in elevated canyons on the western slopes of the San Bernardino and San Jacinto mountains. Trees are few and widely scattered with wide gaps in distribution along borders of perennial streams, bottoms of moist canyons, and gulches. California boxelder is found in strips and patches of pure growth, but commonly grows with white alder, sycamore, and willow. It is a short, stocky tree, growing 20-50 ft tall and is moderately tolerant of shading, especially in its early life. It is dioecious with male flowers in short clusters and females hanging in racemes on separate trees (Jepson, 1923). Female flowers are wind-pollinated and produce finely pubescent samaras with wings that are only slightly divergent (Figure 24).

Big-leaf maple (Acer macrophyllum) is almost entirely restricted to the riparian zone in Southern California, scattered along banks or benches of perennial streams and on spring-rich mountain sides in moist canyons. This handsome, broad-crowned tree can grow to 80 ft tall. Big-leaf maple endures shading well during early life, but grows best and produces the most seed in open woods with good light from above. Flowers are of two kinds, perfect (with stamens and pistils) and staminate, and are found together in the same hanging raceme on the same tree (Jepson, 1936). Fruits are winged samaras that, when dry, disperse by floating on the wind (Figure 25).

California black walnut (Juglans californica) is a deciduous, sometimes-riparian tree native to southeastern Santa Barbara County. It is locally common below elevations of 2,500 ft from the Santa Ynez Mountains southeastward to the Santa Ana Mountains in the watersheds of the Santa Ynez, Ventura, Matilija, Piru-Sespe, and Newhall Rivers. It is also found in the Santa Monica Mountains and on south slopes of the San Gabriel Mountains; on south and west slopes of the San Bernardino Mountains up to elevations of 3,000 ft; in Waterman Canyon up to elevations of 2,900 ft; and on low slopes of the Santa Ana Mountains, its southern limit. A specimen found growing on Cuyamaca Peak in San Diego County is probably not indigenous (Griffin and Critchfield, 1976). A colony of California walnut growing on Jalama Creek in western Santa Barbara County is considered to be a natural disjunct locality (Griffin and Critchfield, 1976). The habitat of the California walnut is similar to that of the California sycamore, namely, the margins of perennial and intermittent streams, usually in moist, gravelly or sandy soil, and sometimes in dry situations where it is sustained by ground-water

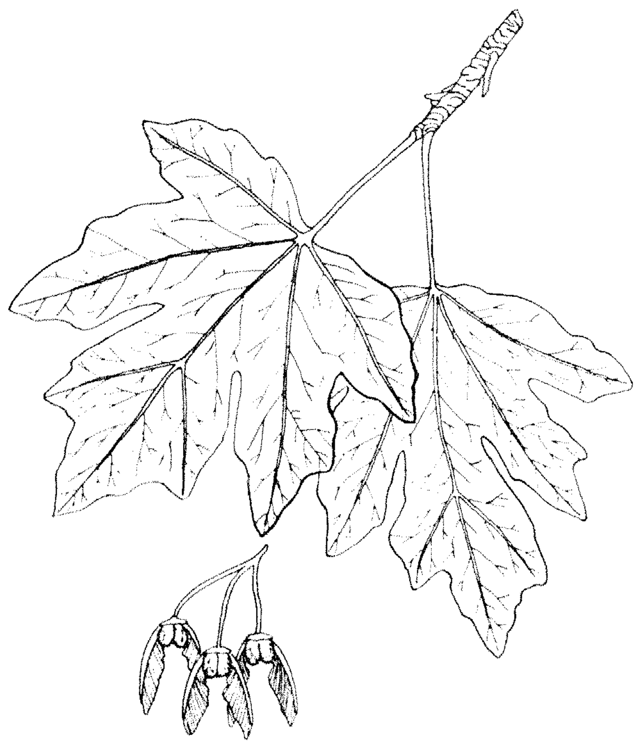


Figure 25. Big-leaf maple (Acer macrophyllum). Drawing by W. Bailey.

Figure 24. Boxelder (Acer negundo). Drawing by W. Bailey.

supplies (Sudworth, 1967). However, it differs from sycamore in that extensive stands are found on foothill slopes not associated with riparian habitats.

Jepson regarded the California walnut in Northern California to be a shrub architecturally, though often of "elephantine proportions," since stems from the base give the appearance of several trunks curving up and then dropping down nearly to the ground. This creates a handsome crown, 12-20 ft high. Small clusters of inconspicuous female flowers are wind-pollinated from male catkins found on the same tree. Fruits develop into nuts that are small but exceptionally hard (Figure 26).

3.4 RARE AND ENDANGERED PLANTS

There are few rare and endangered plants in the riparian community. Rather, the entire community type is endangered by a variety of man's activities, principally agriculture, dam and watershed alterations, road construction, and residential and commercial development. Table 5 shows plants on the California Native Plant Society's List 1b, Rare and Endangered Plants in California (Smith, 1984), that are found in the riparian communities of the study area. Many of these are endemic to small areas and are threatened by human activities.

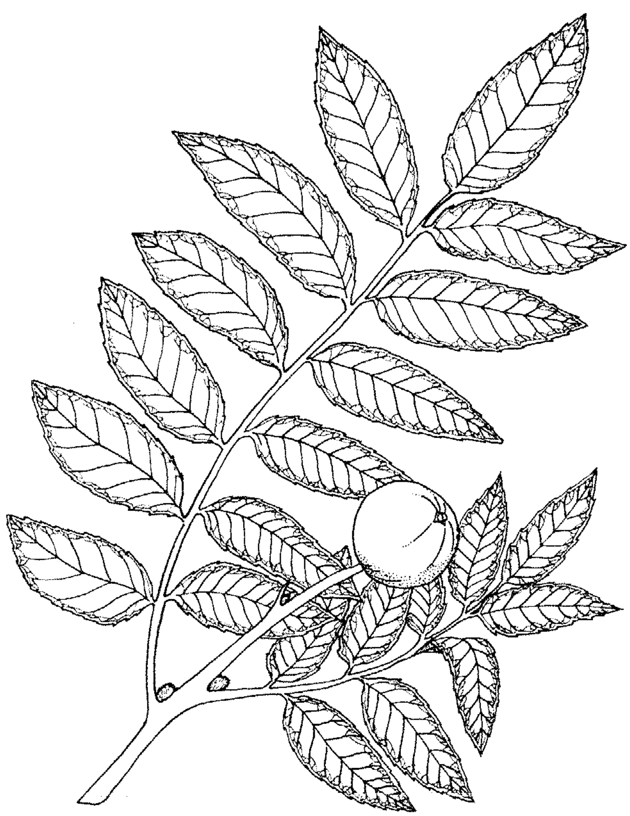


Figure 26. California black walnut (Juglans californica). Drawing by W. Bailey.

3.5 INTRODUCTION AND DISTRIBUTION OF EXOTIC PLANTS

Purposeful introduction of exotic plants into California began in 1769 when Father Junipero Serra established the first European settlement at San Diego. According to Frenkel (1970), at least 16 species of exotic plants were established in California during the period of Spanish colonization from 1769-1824; 63 more species were established during Mexican occupation from 1825-1848; and 55 during American pioneer settlement from 1849-1860. By 1968 Munz and Keck listed a total of 975 exotic plants, most introduced accidentally. New weeds are being established in California continuously; some spread aggressively, while others do not. Some species persist only where irrigation provides needed summer moisture; others become truly naturalized and grow along with or in competition with native species.

There are numerous introduced species in the riparian plant community of Southern California. Zembal (1984a) lists 99 introduced vascular species in a checklist for Prado Basin, Santa Ana River Canyon, and environs, 31.8 percent of the total species found, and 144 introduced vascular species, or 27.6 percent of the total species found, for the Santa Margarita River watershed.

Three introduced species in the riparian plant community of Southern California deserve special mention, as they may eliminate native species of plants and significantly change the character of habitat for wildlife: salt cedar or tamarisk (Tamarix spp.), German ivy (Senecio mikanioides), and giant reed grass or cane (Arundo donax).

Salt cedar (Tamarix ramosissima), a summer-flowering small tree native from eastern Europe to central Asia, was introduced into the United States for

Table 5. Rare and endangered riparian plant species.

Plant name	Location	Status[a]
Delphinium hesperium ssp. cuyamacae (Cuyamaca larkspur)	Cuyamaca Lake	CDFG rare CNPS rare and endangered
Downingia concolor var. brevoir (Cuyumaca Lake downingia)	Cuyamaca Lake	CDFG endangered CNPS rare and endangered
Dudleya densiflora (Santa Gabriel Mts. dudleya)	San Gabriel Mts.	CNPS rare and endangered
Dudleya multicaulis (many-stemmed dudleya)	L.A., Orange, Riv., San Bern., San Diego Counties	CNPS rare and endangered
Eriastrum densifolium ssp. sanctorum (Santa Ana River woolly-star)	San Bern. Co.	CNPS rare and endangered
Limnanthes gracilis var. parishii (Parish's meadowfoam)	San Diego Co.	CDFG endangered CNPS rare and endangered
Mahonia nevinii (Nevin's barberry)	L.A., Riv., San Bern., San Diego counties	CNPS rare and endangered
Monardella linoides spp. viminea (San Diego Co. monardella)	San Diego Co.	CNPS rare and endangered
Sidalcea pedata (bird-footed checker mallow)	San Bern. Co.	State & Federal endangered CNPS rare and endangered

[a]CDFG = California Department of Fish and Game; CNPS = California Native Plant Society.

ornamental purposes in the early 1800s and today is the dominant species in many riparian plant communities (Robinson, 1965). It was already well adapted to southwestern riparian systems, particularly those in the desert. Salt cedar is found along many small stream channels in San Diego County, with a particularly large stand, almost 100 percent cover, in the San Diego River in Lakeside near the high school. It invades rapidly after flooding on newly deposited alluvial soils, driving out native willow and cottonwood, particularly when soils dry rapidly after flooding. According to Brothers (1981), salt cedar is better able than the native flora to colonize a habitat created by alteration of the natural runoff regime. It prefers alkaline soils and is quite salt-tolerant. Glands for excreting salt, located on its leaves, enable salt cedar to invade saline soils. The presence of salt cedar promotes salt accumulation on the soil surface that deters germination and growth of native species. Salt cedar matures rapidly and begins producing large numbers of small wind- and water-borne seeds within a year. Its success may be attributable to its prolonged annual seed production and lower moisture requirement compared with native riparian vegetation (Horton, 1972). Salt cedar grows in dense stands and is deciduous. After 15-20 years of growth of stands, fire becomes a real hazard. After a fire, trees sprout from root crowns within a few days. Salt cedar withstands flooding by developing adventitious roots. Anderson and Ohmart (1977) cite records of rapid invasion by salt cedar in the southwest, where it has become the dominant community type.

German ivy (Senecio mikanioides) is a perennial vine that was first recorded in California in 1890. It is found as an introduced exotic from north of San Francisco Bay south to the Los Angeles basin, with only isolated patches occurring farther south at Chula Vista and along creeks in San Diego and Escondido. Heavy infestations grow along coastal streams in Santa Barbara county, particularly in disturbed residential areas. Its slender twining stems reach out and blanket nearby understory vegetation, which eventually dies out (Figure 27). Invasion by German ivy creates a significant habitat change for wildlife.

Giant reed or cane (Arundo donax) is a tall perennial grass, 20-23 ft tall, with broad blades and large, plume-like inflorescences. Introduced from Europe, it is now widely distributed in moist places in desert and cismontane California and has displaced extensive amounts of native vegetation along streams and waterways, particularly at elevations below 1,000 ft.

Figure 27. German Ivy (Senecio mikanioides), an exotic weed that blankets and eventually kills native vegetation, is shown growing along San Jose Creek in Goleta.

It grows into dense, impenetrable thickets along stream margins or on islands. Bird inventories conducted along the San Diego River indicate that it has little habitat value and is apparently not used, even by reed-loving birds. Residents at Fallbrook in San Diego County unsuccessfully tried to eliminate giant reed on one stretch of the Santa Margarita River by manual and chemical means.

3.6 SOUTHERN CALIFORNIA RIPARIAN HABITAT

Because the geographic area of this community profile is so large, with considerable variation in climate and topography, the riparian community contains distinctive variations. Weather and temperature patterns are considerably moderated by cooling winds and fog from the Pacific Ocean along the short coastal streams of Santa Barbara County and the Channel Islands and along ocean-facing streams of the Santa Monica Mountains in Los Angeles County and the Santa Ana Mountains of Orange County. This coastal influence is diminished in the watersheds of streams and rivers that flow longer distances from mountain ranges further inland, notably from the San Gabriel and San Bernardino Mountains, and to a lesser degree from the Coast Range Mountains in San Diego County. The size of watersheds varies from small acreages along the Santa Barbara coast to very large acreages in the San Bernardino Mountains. The vegetation was mapped by Weislander (1929) between 1929 and 1935.

The following section highlights similarities and differences in riparian vegetation from locations within the study area for which information is available. The small number of rare and endangered plants growing in the riparian community are listed. Species information is limited to areas where floristic studies have been undertaken; thus the level and quality of information varies and geographic coverage is uneven. Information about willow distribution is included where available. Distributional patterns of willow species have not been studied; however, more information on factors affecting these patterns would provide useful information for successful restoration efforts. Table 6 provides information on the distribution and abundance of common riparian trees and shrubs in the study area. Appendix D provides examples of riparian habitat in coastal-draining watersheds in the study area where there is access.

3.6.1 Channel Islands

The geographic extent of riparian vegetation on the Channel Islands reflects climatic, size, and elevational differences among islands. Of the eight off-shore islands forming the Channel Islands, only three of the largest, Santa Cruz, Santa Rosa, and Santa Catalina (all between 100 and 150 mi^2 with elevations under 2,400 ft) support riparian communities, and these are depauperate, dominated by a few species of cottonwood and willow (Philbrick and Haller, 1977).

Thorne (1967) noted the presence of both black and Fremont's cottonwood, red and arroyo willow, and elderberry in the riparian communities of Middle Ranch and Cottonwood Canyons on Santa Catalina Island. Similar riparian assemblages occur on Santa Cruz Island, including a half dozen small to medium-sized stands of big-leaf maple (*Acer macrophyllum*) occurring at low elevations on the north side of the island (Philbrick and Haller, 1977). California bay and sycamore, both common species in the Santa Barbara riparian assemblage, are missing from the native flora of the islands (Timbrook, Santa Barbara Botanic Garden, Santa Barbara; pers. comm. 1984). Minnich (1980) reports that a few sycamores were introduced to Santa Cruz and Santa Catalina Islands in the early 20th century. Fossil seeds of California wax myrtle (*Myrica californica*) have been reported on Santa Cruz along Willow Creek, indicating wetter conditions in the past (Chaney and Mason, 1930). About 20 groves of Fremont cottonwood occur on Santa Cruz Island, some forming long gallery forests along streams; willow forms impenetrable stands where there is permanent water. Mulefat commonly occurs along ephemeral stream washes, particularly where there has been severe erosion (Minnich, 1980). There are no rare or endangered plants reported in the riparian community of the Channel Islands.

Table 6. Common riparian plants in coastal drainages of Southern California.

Species	Channel Islands[b]	Coastal Stream (Santa Barbara (County)	Santa Monica Moun-tains	San Gabriel River Whittier North	San Bernardino (Santa Ana River) (marsh)	San Jacinto Mountains	Santa Ana Mountains (Orange County)	Santa Margarita River	San Diego County
White alder (Alnus rhombifolia)	-	c	c	+	+	c	c	c	c (to 300m)
Arroyo willow[a] (Salix lasiolepis)	sc-o sr-o sm-u	a	a	+	+	c (1)	c (1)	a	a
Goodding's willow[a] (Salix gooddingii var. variabilis)	-	r	-	-	+	c (1)	c	o	c
Sandbar willow[a] (Salix hindsiana)	-	o	c	+	+	-	-	o	o
Narrow-leaf willow[a] (Salix exiqua)	-	o		-	-				
Red willow[a] (Salix laevigata var. araquipa)	sc-o	c	c	-	+	-	c (1)	u	c
Yellow willow[a] (Salix lasiandra var. lasiandra)	sc-o	o		+	-	c		o	o
Fremont cottonwood (Populus fremontii)	sc-u	o	c	+	c (i)(1)	c (1)	c	o	c
Black cottonwood (Populus trichocarpa)	sc-o sr-u	c	c	+	c (up to 6700')	u (1)	c	o	c

(Continued)

Table 6. (Continued).

Species	Channel Islands[b]	Coastal Stream (Santa Barbara (County)	Santa Monica Moun-tains	San Gabriel River Whittier North	San Bernardino (Santa Ana River) (marsh)	San Jacinto Mountains	Santa Ana Mountains (Orange County)	Santa Margarita River	San Diego County
California sycamore (_Plantanus racemosa_)	-	a	a	+	+	c (1)	c	c	c
Coast live oak (_Quercus agrifolia_)	c	a	a	+	+	+	c	c	c
Boxelder (_Acer negundo_) var. _californicum_)	-	o	u (i)	+	-	o	-	-	u (above 450m)
Bigleaf maple (_Acer macrophyllum_)	sc-o	c	c	+	+	-	c (1)	-	u (above 450m)
California black walnut (_Juglans californica_)		o	c	+	+	-	o	u	u
Flowering ash (_Fraxinum dipetala_)	-	r (above 3000′)	r	-	+	-	c (1)	-	u
Oregon ash (_Fraxinum velutina_ var. _coriacea_	-	u	u	+	+	-		u	u
Brown dogwood (_Cornus glabrata_)	-	u	-	-	-	-	-	-	u (above 1200m)
Western dogwood (_Cornus occidentalis_)	-	o	-	+	-	u (i)	-	-	o (above 950m)
Western azalea (_Rhododendron occidentale_)	-	-	-	-	-	c	-	-	o (above 500m)

(Continued)

Table 6. (Concluded).

Species	Channel Islands[b]	Coastal Stream (Santa Barbara (County)	Santa Monica Moun-tains	San Gabriel River Whittier North	San Bernardino (Santa Ana River) (marsh)	San Jacinto Mountains	Santa Ana Mountains (Orange County)	Santa Margarita River	San Diego County
Mulefat (_Baccharis glutinosa_)	an-o sc-o sr-o	c	c	+	+	c (l)	?	c	c (below 1100m)
Elderberry (_Sambucus mexicanus_)	sc-o	o	o	+	+	c	-	o	o
Wild grape (_Vitis girdina_)	-	r	o	+	+	-	o (l)	c	c (below 1200m)
Creek clematis (_Clematis ligusticifolia_)	sc-o sr-o	c	o	-	+	-	-	-	o
Wax myrtle (_Myrica californica_)	sc-c	o	o	-	-	-	-	-	-
California bay (_Umbellularia california_) shrubby form						c (l)	c (l)	c (l)	o

Legend

Abundant	a
Common	c
Occasional	o
Uncommon	u
Rare	r
Not found	-
Present	+
Introduced	i
Lower elevation only	l

[a]Montane species of _Salix_ not included

[b]Channel Islands

Anacapa	an
Santa Cruz	sc
San Miguel	sm
Santa Rosa	sr

[c]Fossil seeds

3.6.2 Coastal Streams in Santa Barbara County

Coastal streams in Santa Barbara County drain the southern slope of the Santa Ynez Mountains in the Transverse Range and flow into the Pacific Ocean within a few miles of their origin. These mountains rise to elevations of around 4,000 ft, so several thousand ft can separate the upper limits of a stream watershed and sea level. Nearly continuous winds and south-facing slopes combine to create xeric soil conditions, which are somewhat modified by moist coastal fog (Fletcher, 1983).

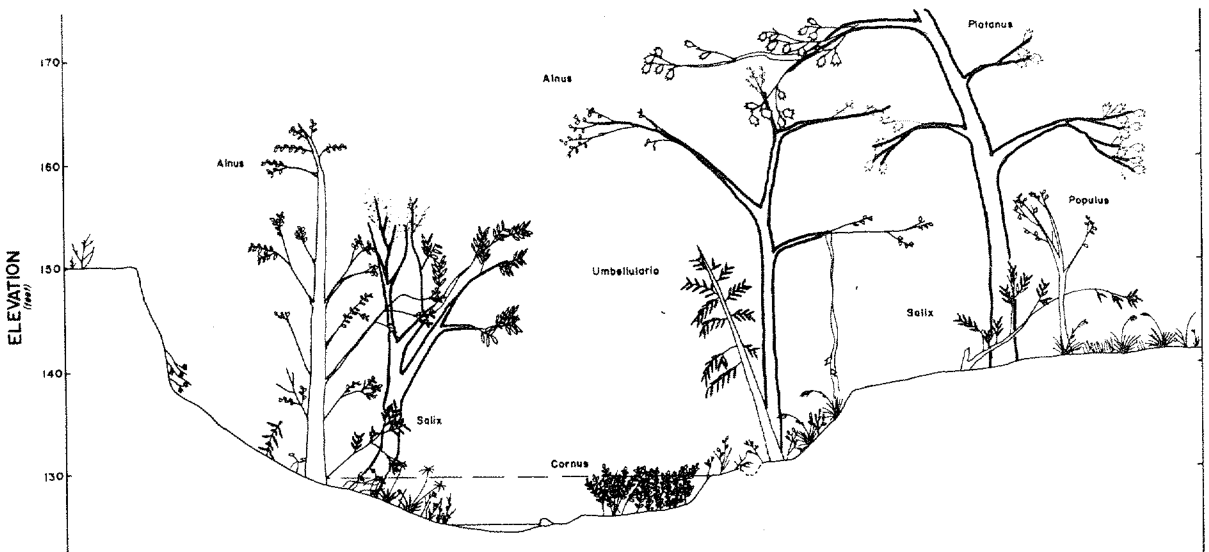
Hollister Ranch, covering the most western portion of the study area, extends 8.5 mi eastward from Point Conception to Gaviota, 25 mi west of Santa Barbara, and from the mean high-tide line to the crest of the Santa Ynez Mountains. A flora of this ranch lists scrub/shrub wetlands on saturated, seasonally or temporarily flooded soils along streambanks of upper canyons, seeps, and some lower canyons. Arroyo willow is the dominant plant species. Forested wetlands are found along streambanks and seeps on north-facing slopes in Alegria, Quarta, and Santa Anita Canyons, with sycamore, black cottonwood, coast live oak, red willow, yellow willow, and arroyo willow all listed as dominant types (Fletcher, 1983). Extensive grazing, fire-prevention practices, and clearing for avocado groves have degraded or eliminated much of the riparian habitat on the ranch (Fletcher, 1983).

Four coastal streams that drain the southern slope of the Santa Ynez Mountains in the Goleta Valley watershed in Santa Barbara County were studied before a U.S. Army Corps of Engineers flood-control project was started (Ferren, 1984). Upstream acreages adjacent to these streams are largely planted in avocados, whereas land adjacent to downstream acreages is residential and commercial/industrial. San Jose Creek supports the most diverse assemblage of riparian vegetation of any of the four creeks studied (Figure 28). Dominant trees and shrubs include white alder, western sycamore, black cottonwood, red willow, yellow willow, arroyo willow, and California bay. California live oak is common along upper streambanks and extends into upland communities. Arroyo willow is the most common tree or shrub, particularly toward the floodplain; toyon is found occasionally in the streambank community, whereas big-leaf maple is rare throughout the Santa Barbara coastal-stream study area. Yellow willow, rare at low elevations and increasing in frequency upstream, dominates a narrow low-elevation floodplain. Seedlings of white alder and black cottonwood appear scattered through the understory, suggesting that, if left undisturbed, the existing dominance of yellow willow may be altered in the future (Ferren, 1983).

Dominants of the shrubby understory include virgin's bower (<u>Clematis ligusticifolia</u>), red osier dogwood (<u>Cornus stolonifera</u>), a scrub form of black cottonwood, coffeeberry (<u>Rhamnus californica</u>), California blackberry (<u>Rubus ursinus</u>), arroyo willow, and poison oak. Habitat preferences are observed among these shrubs. For example, dogwood is restricted to seasonally flooded areas, arroyo willow and black cottonwood grow as scrub vegetation in streambeds or along low banks, and blackberry and poison oak usually grow on banks, slopes, and terraces (Ferren, 1983). There are no rare or endangered plants reported for the riparian community of coastal Santa Barbara County.

3.6.3 Coastal Streams of the Santa Monica Mountains

The Santa Monica Mountains extend east-west for 47 mi from Griffith Park in Los Angeles to Point Mugu and from the Pacific Ocean on the south approximately 7 mi north to the San Fernando and Simi valleys. The mountain range is young geologically with highest elevations of about 2,800 ft. Slopes are steep (80 percent are in excess of 25 percent gradient) and there are 49 short coastal streams that are all highly erosive. In addition, the area is particularly subject to major wildfires fueled by the Santa Ana winds, a seasonal weather phenomenon of Southern California, and by a combination of steep slopes and highly combustible vegetation (U.S. National Park Service, 1983). The southern half of the mountain range is now included within the boundary of the Santa Monica Mountains National Recreation Area, and acquisitions are being added by State, Federal, and private agencies. Some



PERCENT COVER

SPECIES																				
ALNUS RHOMBIFOLIA				30	40	50	5													
PLATANUS RACEMOSA	10										60	72	70	5						
POPULUS TRICHOCARPA								10	85	90					90	81	60	87	85	30
SALIX LAEVIGATA							25	15	10											
SALIX LASIOLEPIS					2	20	2					14	15			19	40	13		
UMBELLULARIA CALIFORNICA												14								
SUBTOTAL	10	0	0	30	42	70	32	25	95	90	60	100	85	5	90	100	100	100	85	30
ARTEMISIA DOUGLASIANA				15	5														3	
CORNUS STOLONIFERA										90	50	3								
POPULUS TRICHOCARPA										5	50	90	90	90						
RUBUS URSINUS			20			20	5													
TOXICODENDRON DIVERSILOBUM					5	20	20													
SUBTOTAL	0	0	20	15	10	40	25	0	0	95	100	93	90	90	0	0	0	0	3	0
BROMUS CARINATUS																		30		
BROMUS DIANDRUS																		30	10	91
CYPERUS ALTERNIFOLIUS						10	10													
MALVA PARVIFLORA																			10	
MARAH FABACEUS													1	40						
ORYZOPSIS MILIACEA													5	1				10	15	9
PENNISETUM CLANDESTINUM						5	85					50	1							
RAPHANUS SATIVUS	5																		2	
SONCHUS OLERACEUS	20																			
TROPAEOLUM MAJUS					10															
SUBTOTAL	25	0	0	0	10	15	95	0	0	0	0	50	7	41	0	0	0	70	37	100
TOTAL	35	0	20	45	62	125	152	25	95	185	160	243	182	136	90	100	100	170	125	130

T - 8: SAN JOSE CREEK

0 3 6m
0 10 20ft

Figure 28. A cross section of San Jose Creek in Goleta Valley (Ferren, 1984).

riparian vegetation occurs along many canyon bottoms, but riparian habitat is specifically noted in the National Park Service Plan (1983) for the following canyons: Corral, Trancas, Tuna, Pera, and Solstice.

White alder is infrequent, found only in the lower parts of steep canyons along perennial streams. Arroyo willow is abundant and is the dominant riparian species, particularly in flood-plain areas. Red willow is common throughout the riparian corridors at higher elevations where it is less susceptible to flooding (Thomas, 1984). Sandbar willow (Salix hindsiana) is not found within the National Recreation Area, but is present at low elevations along the north side of the range along riverbeds and to the west bordering salt marshes. Goodding's and yellow willow are not found in the Santa Monica Mountains (Raven and Thompson, 1966). Big-leaf maple is found only in north slopes near springs on ridges at 2,000 ft or higher where water collects and cold air flows down canyons. The Santa Monica Mountains are the center of distribution for California walnut, which grows on moist riparian terraces and onto north-facing slopes (Thomas, 1984; Minnich, 1980). Flowering ash (Fraxinus dipetala) and F. velutina var. coriacea are both found only on the inland side of the high central and western portion of this range. No rare or endangered plants are reported in the riparian community of the Santa Monica Mountains.

3.6.4 Ventura and Santa Clara Rivers

Both the Ventura and Santa Clara Rivers drain parts of the Los Padres National Forest in the Transverse Range where a number of peaks exceed elevations of 5,000 ft. Upper reaches of the Ventura River, such as Matilija Creek, drain canyons of Old Man Mountain and Nordhoff Ridge and are relatively undisturbed, but when these creeks descend into the valley they form a wash at about 1,000 ft (Figure 29). Orange and walnut groves are planted right up to the edges of the wash. Willow, eucalyptus, and cane grow in scattered places along the

Figure 29. Narrow corridor of riparian vegetation reveals the presence of a stream descending into the Ventura River.

wash and occasionally along the edge of the river, which is channelized closer to the ocean.

The Santa Clara River is a long river flowing east-west. It is fed by several streams flowing south out of the San Rafael Mountains in the Transverse Range in Ventura and Los Angeles Counties. A comparison of aerial photographs of the lower Santa Clara River from 1927, 1941, 1969, and 1979 shows that much of the middle- and upper-terrace zones had already been converted to agriculture by 1927 (Fairchild Aerial Photograph Collection, Whittier College). The distribution and gross extent of riparian woodlands, the characteristic vegetation of higher terraces, have not diminished markedly over the last 50 years; however, in recent years, activities such as off-road vehicle traffic, mining, natural flooding, and urban development have resulted in thinning and fragmentation of these woodlands. The disturbed nature of the vegetation at the mouth of Santa Paula Creek exemplifies such damage. The major difference in the nature of the river vegetation between 1927 and today, as reflected in the photographs, is the current absence of riparian thickets on the flood-plain and low gravel bars in many places. Past photographs show that such thickets were once characteristic of the entire riverbed. At present, gravel-bar vegetation is extremely sparse or lacking, especially in the vicinity of mining operations, due in part to natural scouring and in part to lowered water tables caused by gravel in mining.

Mature, undisturbed riparian woodlands are located on terraces above the riverbed and are most frequent downstream from the Highway 101 bridge and upstream from Santa Paula Creek, with a few scattered patches between. Poorly developed riparian vegetation occurs on recently flooded gravel bars, along the main channel throughout the length of the river, and on terraces in the vicinity of gravel extraction operations. Mature, undisturbed riparian woodlands are located 10-12 ft above the river bed and are structurally diverse (Smith, 1979). Tree strata, 30-60 ft high, consist of arroyo willow, red willow, black cottonwood, and occasional Fremont cottonwood. Thickets of giant reed, mulefat, and young willows grow beneath this dense tree canopy, and a diverse understory of native vines such as poison oak, blackberry, and herbs develops. An ecologically important type of riparian vegetation grows around undisturbed siltation ponds and natural depressions along the Santa Clara River banks (Smith, 1979). Standing water in these areas allows the development of a freshwater marsh containing plants such as cattail (<u>Typha</u> spp.), bulrush (<u>Scirpus</u> <u>robustus</u>), sedge (<u>Carex</u> spp.), rush (<u>Juncus</u> spp.), and numerous aquatic species that provide important habitat and food for waterfowl.

Numerous creeks drain vast areas of the Transverse Range to the north, much of which is included in the Los Padres National Forest. Santa Paula Creek, a short system, is unaffected at its upper reaches, but the riparian vegetation located at its confluence with the Santa Clara River is arrested at an immature state from past gravel-mining operations, which lowers water tables, and by natural flooding. Habitat here is sparse and disturbed (Smith, 1979). Sespe Creek, the longest of the tributary creeks and undammed to date, flows from east to west from a point near the border between Santa Barbara and Ventura Counties through the Los Padres Forest Condor Refuge, where it turns south and joins the Santa Clara River. Riparian habitat is reduced by the frequency and severity of floods and by cattle grazing. Piru Creek drains a vast area to the north in the Los Padres National Forest. It is dammed at Santa Felicia, creating Lake Piru. Mature riparian habitat along both creeks and their tributaries is disturbed, principally by extensive grazing. No studies have been made of species composition in these vast areas, and no rare or endangered plants are reported for riparian habitat.

3.6.5 <u>San Gabriel Mountain Range</u>

The San Gabriel Mountains, part of the larger Transverse Range, extend from the Ridge Route of I-5 and Soledad Canyon (California Route 14) on the west to Cajon Pass (Interstate 15) on the east and occupies the northern fourth of Los Angeles County and a small portion of southwestern San Bernardino County. Most of this range, which has an east-west orientation, is within the Angeles National Forest; the extreme eastern part is within the San Bernardino National Forest. Elevations in the San Gabriel Mountains are high, 800-10,000 ft, and watersheds are drained on the coastal side, forming three major rivers: to the west, Tujunga Creek and its tributaries form the Los Angeles River; in the central portion of the mountain, San Gabriel Creek and its tributaries form the San Gabriel River; and to the east Lytle Creek in San Bernardino County joins drainages from the San Bernardino Mountains to form the Santa Ana River. Each of these rivers flow many miles across the broad and highly urbanized Los Angeles floodplain before emptying into the Pacific Ocean. According to photographs in the Fairchild Aerial Photo Collection, Whittier College, all three rivers were channelized before 1927.

Riparian woodlands are severely restricted by the availability of water from perennial streams or subsurface moisture in the semiarid climate of the San Gabriel Mountains and stand out in sharp relief against adjacent low-growing scrub and shrub lands. At elevations of 2,000-5,000 ft, the riparian community contains elements of a mixed evergreen forest found in the Coast Ranges, particularly in cold canyons (Hanes, 1976). Dominant species include shrubby forms of Salix, big-leaf maple, California bay, black cottonwood, canyon live oak (Quercus chrysolepis), and big-cone Douglas fir (Pseudotsuga macrocarpa). At middle elevations, streams are dominated by white alder, and at low elevations on riparian terraces by arroyo willow, mulefat, Fremont cottonwood, and western sycamore (Hanes, 1976). Mistletoe (Phoradendron tomentosum subsp. macrophyllum) is a common hemiparasite on dominant tree species. Coast live oak grows on upper riparian terraces, particularly north-facing ones, some distance from perennial water supplies.

As creeks emerge from the San Gabriel Mountains onto gravelly alluvial floodplains, there are remnants of a vast alluvial scrub habitat that once covered much of the Los Angeles Basin, particularly on higher terraces less subject to severe scouring in major storms (T.L. Hanes, pers. comm.). Most of the streams draining directly onto this floodplain are now dammed. Aerial photographs of the flood basin reflect the presence of three physiographic zones of different ages that support distinct types of vegetation: a wash, a terrace above the wash, and a higher alluvial terrace (R.L. Smith, 1980). The youngest zone, the wash, supports scattered, short-statured pioneer species and contains islands or remnants of a higher alluvial terrace, most of which has been destroyed by erosion during past floods. These older islands now support large shrub populations. The terrace immediately above a wash supports a uniform and dense scrub vegetation dominated by buckwheat (Eriogonum fasciculatum). The highest zone of the floodplain, mature alluvial terraces, and the uneroded alluvial islands support a combination of shrubs and subshrubs that distinguishes the fan and floodplain vegetation by its rich diversity (Smith, 1980). Laurel sumac (Rhus laurina), lemonadeberry (R. integrifolia), Lepidospartum squamatum, California buckwheat (Eriogonum fasciculatum), California juniper (Juniperus californica), and prickly pear (Opuntia spp.) are the dominant species.

Mature stands are diverse and appear to represent a climax vegetation that develops after severe periodic flooding. R.L. Smith (1980) regards this plant assemblage as a specialized form of coastal sage scrub. Lepidospartum squamatum is the one species of this plant assemblage that is restricted to alluvial substrates and is thus confined to drainages. On the other hand, Juniperus californica is unusual on the floodplain, growing more typically on desert slopes (Munz, 1974). Smith suggests that major drainages such as the San Gabriel River act as corridors for dispersal of juniper seed from dry interior mountain slopes. Dominance of lemonadeberry, primarily a coastal species, is unusual this far inland.

With the exception of a remnant of riparian woodland habitat heavily invaded by exotic plants at Whittier Narrows County Nature Center, nothing remains of a once-extensive willow forest that followed the San Gabriel River across its floodplain. Intermittent immature stands of willow and mulefat now grow in wash areas on upper parts of the river.

The Los Angeles Water District routinely cuts water-loving riparian trees to reduce water loss through transpiration. There are no rare or endangered plants reported in the riparian community of the San Gabriel River; however, San Gabriel Mountain dudleya (Dudleya densiflora), a rare and endangered plant (CNPS List 1b, J. Smith and York, 1984) grows on rocky cliffs above perennial streams between 800 and 2,000 ft elevation in Fish and San Gabriel canyons (Figure 30).

Aside from work by Brothers (1984) on plant distribution gradients, by Smith (1980) on the specialized alluvial terrace community, and a taxonomic and ecological study of the San Gabriel River Canyon by Robinson (1953), remarkably little work has been done in the San Gabriel Mountains, considering the proximity of such a dense population.

3.6.6 San Bernardino Mountain Drainage

The San Bernardino Mountains, a continuation of the Transverse Range drained principally by the Santa Ana River, extends eastward from Cajon Pass (I-15) to Morongo Valley. Elevations range from 11,500 ft at San Gorgonio Mountain, the tallest mountain in Southern California, to 4,800 ft at Lake Gregory and 8,300 ft north of Big Bear Basin. The southeastern corner of the range comprises prominent granite blocks set apart by east-west canyons, through which its major watercourses flow. Mill Creek and the Santa Ana River converge at Mentone and flow across the broad Chino Basin, where they are joined by Lytle and San Timateo Creeks and their tributaries that flow through the Santa Ana Canyon and across the Orange County plain to the Pacific. The Santa Ana River has been straightened and channelized from Weir

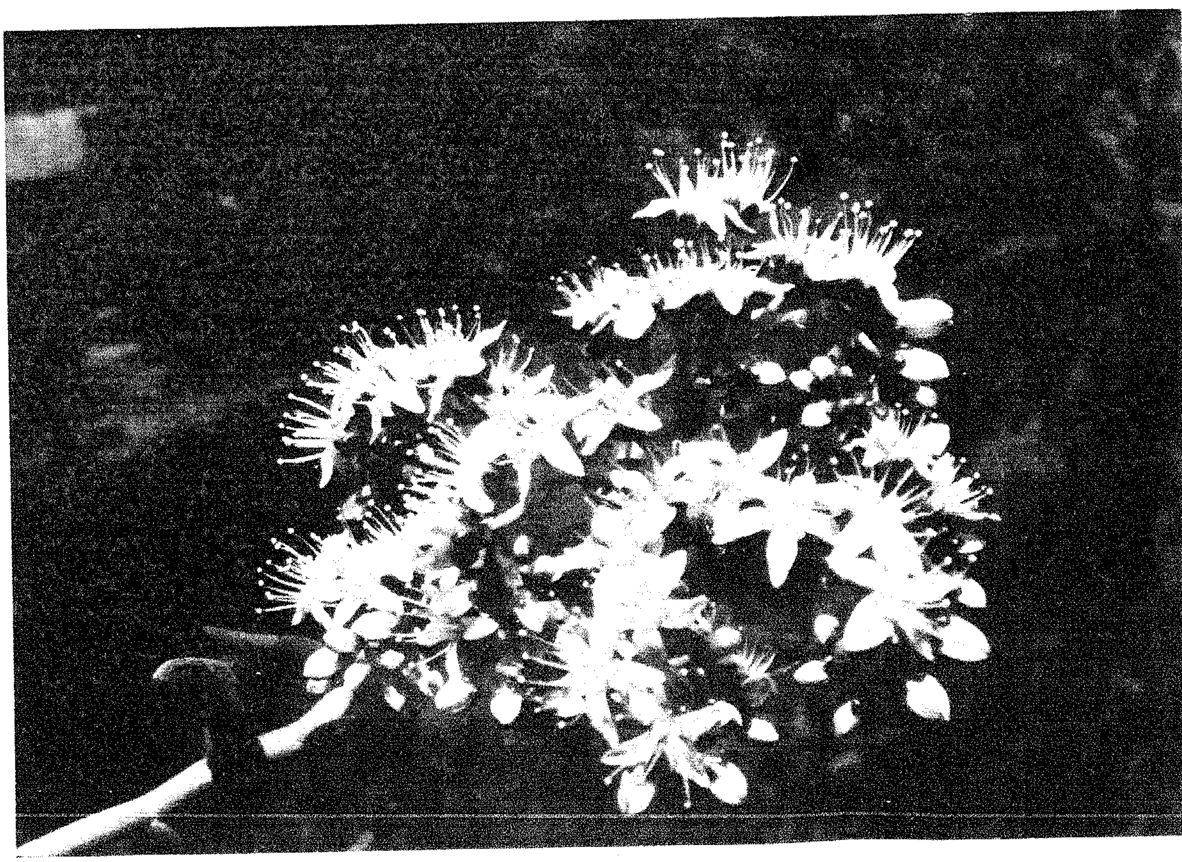


Figure 30. Mountain dudleya (Dudleya densiflora), a rare and endangered plant, grows on rocky cliffs above a perennial stream in Fish and San Gabriel canyons. Photograph by Tim Krantz.

Canyon Road near Yorba Linda to the ocean in work that was carried out largely before 1927 (Fairchild Photo Collection). Prado Dam was built at the head of Santa Ana Canyon in 1941.

Because of the large size and high elevations of the upper watershed, winter flooding, though infrequent, can be severe. Storms tore out vast stands of willow forest, alder, and other vegetation in 1938, 1962, and 1969 (Minnich, 1976). The Santa Ana River, Mill Creek, Plunge Creek, and City Creek all emerge from their canyons in the foothills of the San Bernardino Mountains at Mentone, forming a floodplain alluvial wash 10 mi long and an average of 2 mi across with a riverbed 0.5 mi wide. Where Mill Creek emerges the elevation is 3,000 ft; where the wash ends the elevation is 1,100 ft (Ingles, 1929). A riparian alluvial scrub community dominated by <u>Lepidospartum squamatum</u>, <u>Croton californicus</u>, young willow, and mulefat forms scattered patches throughout the wash. A study area described by Ingles in 1929 was not identifiable, partly because of major storms in 1932 and 1969 which devegetated the wash and partly because of extensive replacement of willow, sycamore, and oak terrace vegetation by agriculture and housing. A few specimens of western sycamore, black willow, cottonwood, and coast live oak, some heavily festooned with wild grape, remain on upper river terraces mixed with exotics such as <u>Eucalyptus</u> spp. Where not replaced by agriculture of housing, a coastal chaparral and coastal sagebrush community intergrades with the riparian community.

Most of the riparian plants above 7,000 ft elevation are shrubby species of <u>Salix</u>. They are well adapted to heavy winter snows characteristic of high elevations. Minnich (1978) reports willows, flattened by avalanches, springing up vertically the following summer. Grinnell (1908), a zoologist working in the San Bernardino Mountains in the early 1900s, reported arroyo willow to be abundant along all streams to the head of the Santa Ana River (6,800 ft elevation) and black willow to be found growing to large tree size on the upper Santa Ana at 6,000 ft elevation and on Fish Creek at 6,900 ft.

The U.S. Forest Service (USFS) has mapped the vegetation of order III streams in the San Bernardino National Forest (USFS 1984). The most widespread and best adapted riparian tree is white alder, which is often found in the middle of boulder-strewn washes between 2,900 ft and 7,000 ft elevation (Minnich 1976). Most populations were devastated in a 1969 storm, but many young trees now grow along stream channels. Occasionally a mature tree remains on a higher terrace. Grinnell (1908) reported that alders grew luxuriantly along most Pacific Slope watercourses; he described them on the upper slopes of the Santa Ana River as lining either side of the river and "meeting overhead to form a dense and almost continuous canopy." In deep canyons, sheltered from wind, they become tall and straight; in broad open valleys and at higher elevations they are more scrubby (Grinnell, 1908). While there is some undisturbed or moderately disturbed habitat in this area today, "dense and almost continuous canopy" is a rarity.

Fremont cottonwood is found intermittently along many watercourses below 7,000 ft, whereas black cottonwood (<u>Populus trichocarpa</u>) is rare (Minnich, 1976). One individual can be seen from Highway 38 in the Santa Ana River Canyon at 7,400 ft. Grinnell reported black cottonwood to be abundant along canyons of the Pacific Slope from the foothills up to 6,700 ft elevation on the upper Santa Ana. He thought the examples of Fremont cottonwood to be seen below Mill Creek had been planted (Grinnell, 1908). Whereas the genus is well represented in the San Bernardino Mountains flora, it is rare in terms of cover (Minnich, 1976). A disjunct single stand of quaking aspen (<u>P. tremuloides</u>) occurs along Fish Creek in the San Gorgonio Wilderness Area; it is the only confirmed stand between the southern Sierra Nevada and the Sierra San Pedro Martir of northern Baja California (Grinnell, 1908; Minnich, 1976).

Western sycamore grows in scattered fashion along most wash bottoms and many terraces below 4,000 ft. Sycamore dwindles in size as it approaches 3,000 ft in elevation (Grinnell, 1908). Big-leaf maple is more common in smaller drainages and on side banks above stream channels that are subjected to less intense erosional disturbance.

More rare riparian plants include dogwood (Cornus nuttallii), which occurs along watercourses and on shaded slopes near Lake Arrowhead and Lake Gregory. A few populations of boxelder grow on north-facing canyons on Mill Creek Ridge and Oak Glen. Mountain maple (Acer glabrum) has been reported on the north face of Sugarloaf Mountain near 10,000 ft elevation (Minnich, 1976). Grinnell (1908) reported that nettle (Urtica holsericea), which grew 5 to 6 ft tall, was abundant along streams wherever shaded by alder canopy and that clematis (Clematis ligusticifolia) grew at elevations of up to 6,500 ft.

The riparian woodland in the Prado Basin is the largest in Southern California. A USFWS study (Zembal, 1984a) of this basin, the Santa Ana River Canyon, and environs points out that a small number of species accounts for much of the plant cover. A total of 99 species were identified in floodplain and riparian habitats. Approximately one-third of the plants in the study were identified as introduced or non-native species.

Two small and widely separated populations of the rare many-stemmed live-forever (Dudleya multicaulus) (CNPS List 1b, J. Smith and York, 1984), growing on nearly vertical rock or dirt walls in the river canyon are threatened by development. Santa Ana River eriastrum (Eriastrum densifolium), thought to have been extirpated, was found in a nearby canyon (Lathrop and Thorne, 1978). Recently a few stands were located in the northern portions of the plant's historic range growing above main watercourses where flooding and scouring have been infrequent enough to allow open shrublands to persist in the floodplain. Zembal and Kramer (1984) estimate that suitable habitat for the plant has been reduced by 90 percent. Both species are proposed for Federal listing under the Endangered Species Act.

Black willow is very common along the Santa Ana watercourse and throughout the basin; sandbar willow is common along watercourses growing in scattered dense stands; and arroyo willow is found occasionally along some basin watercourses and commonly along others. Red willow and black cottonwood are uncommon along the Santa Ana River Canyon, and Fremont cottonwood and sycamore are uncommon but locally conspicuous along the outer fringes and higher ground of the watercourses, often growing in groves of several to several dozen trees. Flowering ash is uncommonly found in the undergrowth, and California walnut is present but uncommon in the bordering shrubland (Zembal, 1984b).

Below Prado Dam, built in 1941, remnants of perennial stream riparian vegetation remain, particularly in Featherly County Park, situated on an alluvial plan (Marsh and Abbott, 1972). Along this portion of the river elevational gradients are reduced, resulting in ponding and the development of a sizable instream flora, including bur-marigold (Bidens laevis), watercress (Rorippa nasturtium-aquaticum), cattail (Typha spp.), and bulrush (Scirpus spp.). Cottonwood, willow, and mulefat dominate a dense greenbelt of trees and shrubs lining the river margin. Older trees are commonly festooned with wild grape, which creates shade for a rich understory of herbaceous annual and biennial species. Sycamore and coast live oak grow to large sizes on upper terraces, supported by a high water table.

Marsh and Abbott (1972) list 367 species of plants in a study covering 31 mi of the lower Santa Ana River from Prado Dam to the river mouth. These plants belong to 252 genera and represent 72 families. Of the total number of species, 229 are native and 138 are exotic. There are 62 species in the sunflower family and 11 species each of sedges and buckwheat. In transects across the river in the Horseshoe Bend/Featherly Park area 250 plant species were identified, many of which are listed in Howell (1929) and many introduced since then (Marsh, 1972). Figure 31 shows a cross section of the Santa Ana River between Horseshoe Bend and Featherly Park.

3.6.7 San Jacinto Range

The San Jacinto Range, approximately 40 mi long and 15 mi wide, is separated from

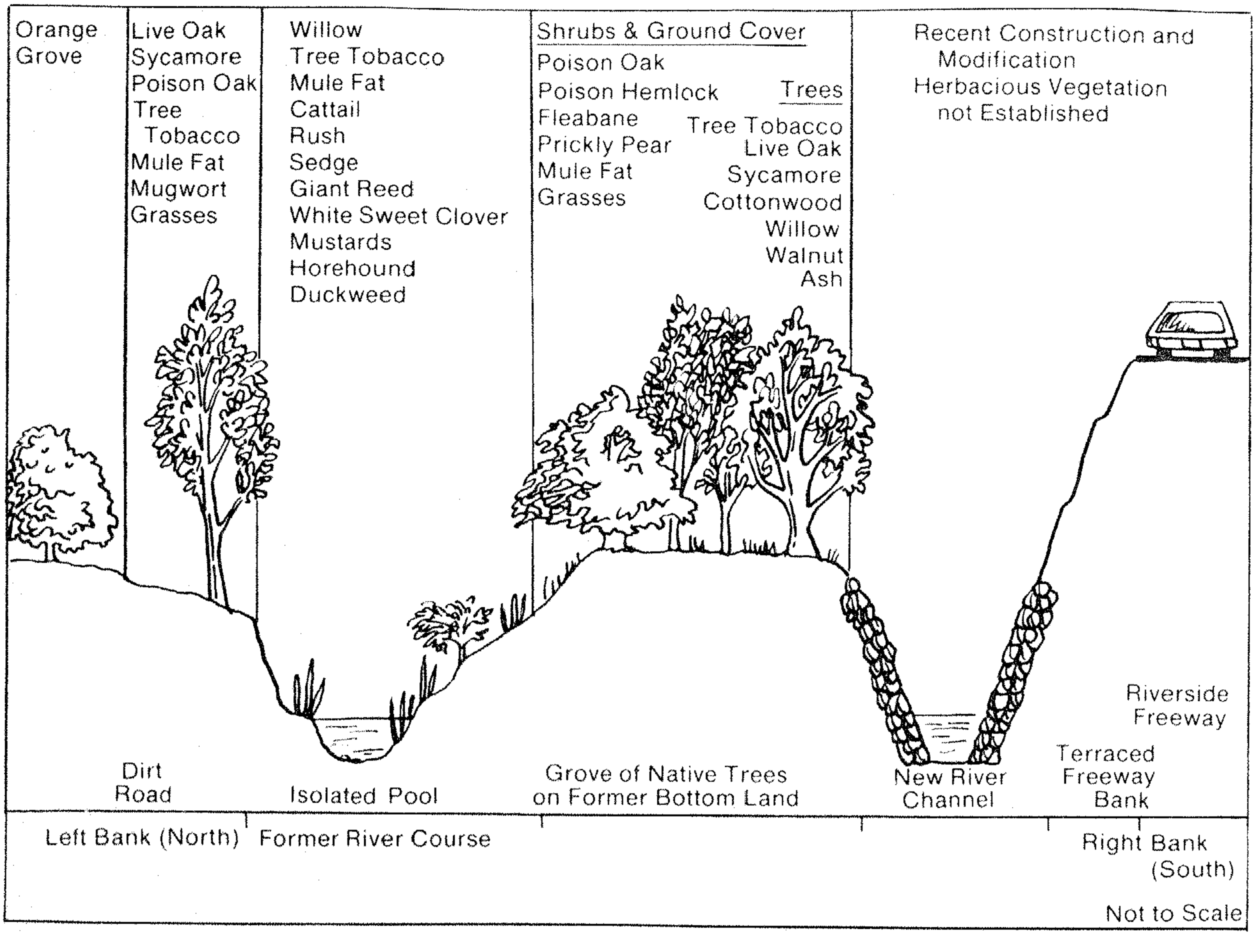


Figure 31. Cross section of the Santa Ana River between Horseshoe Bend and Featherly Park (adapted from Marsh, 1972).

the San Bernardino Range by the trough-like San Gorgonio Pass, through which runs the San Andreas fault. At 10,831 ft, San Jacinto Peak is the second highest in Southern California. The range, forming the beginning of the Peninsular Ranges, runs southeast, on the east rising precipitously from the Colorado Desert in the upper Coachella Valley and on the west from a series of foothills, low ranges, solitary peaks, and occasional valleys. On the south, the San Jacinto Mountains grade into the Santa Rosa Plateau and Mountain Range. The entire range is within Riverside County, and most is within the San Bernardino National Forest with ownership shared by the USFS, the State, various Indian tribes, and some private inholdings.

The most extensive drainage is toward the west in the north fork of the San Jacinto River and its tributaries, many of which are perennial streams. Flooding is common in years of heavy rainfall because of the large quantities of water carried in winter and spring. The most extensive riparian community occurs on the moist western slopes, particularly on the fairly level benches at middle elevations. Stands of white alder frequently line fast-flowing perennial streams. Yellow willow grows intermittently along stream courses throughout the higher mountain drainages. At higher elevations dense assemblages of herbaceous perennials surround wet springs, with plants such as _Senecio triangularis_ and several species of _Epilobium_ predominating. Twayblade (_Listera_ convallarioides), a rare plant for this area, grows at about 8,000 ft near the north fork of the San Jacinto River (Hamilton, 1983). Below 8,000 ft, arroyo willow grows along streams in the wider canyons in patches where small benches slow the water flow. The riparian understory is sparse, with western azalea (Rhododendron occidentale), elderberry, and Ribes spp. growing occasionally. Below Lake Hemet to the Cranston Ranger Station, riparian habitat is relatively pristine. Elements of the Sonoran Desert flora merge into the riparian plant assemblage at lower elevations with Opuntia spp. growing commonly, Yucca whipplei and Agave spp. less frequently (Hamilton, 1983). Willows become lush as creeks merge and flow out onto the wide alluvial floodplain. Remnants of alluvial scrub habitat can be seen on higher terraces. Below the ranger station there is frequent disturbance and only a patchy canopy of cottonwood and sycamore remains. Occasional large and usually old specimens of these trees remain on an increasingly urbanized floodplain.

3.6.8 Santa Ana Mountains

The Santa Ana Mountains parallel the southeastern trend of the Southern California coastline; they are approximately 40 mi long, vary in width from 4 to 13 mi, and are located 20-25 mi inland from the ocean. This narrow and precipitous range has an average height of 3,500 ft and several peaks with elevations exceeding 5,000 ft. Most of the range straddling Orange and Riverside Counties is in public ownership in the Cleveland National Forest, with private holdings for homes and cabins in Silverado and Trabuco Canyons and cattle ranching in the western foothills and Black Star Canyon.

Santiago and Trabuco Creeks are the main streams draining the mountains to the west. In 1951 Pequegnat referred to these streams as perennial, whereas in 1976 Vogl described them as intermittent. Short ephemeral streams feed into the larger streams and drain the eastern side (Vogl, 1976). Larger stream drainages are lined with occasional stands of white alder and an abundance of willow and Fremont's cottonwood (Vogl, 1976). Black cottonwood is less common but occurs throughout the range (Lathrop and Thorne, 1978). Poison oak and wild grape often grow in willow and mulefat thickets. Clematis ligusticifolia is found infrequently climbing over shrubs. With an increase in altitude, alder is replaced by big-leaf maple, and lowland willow by arroyo willow (Pequegnat, 1951).

Smaller streams are flanked with coast live oak and California bay; flowering ash is scattered throughout. Canyon oak (Quercus chrysolepis) and interior live oak (Q. wislizenii) are present at higher elevations and at heads of canyons, where they often form pure stands of a single species. Dense stands of canyon oak have stabilized some of the steepest parts of Modjeska and Santiago Peaks (Vogl, 1976). California walnut is found infrequently in the riparian woodlands, mainly in Hagador, Santa Ana, and lower San Juan Canyons (Lathrop and Thorne, 1978).

3.6.9 San Diego County Coastal Rivers

The coastal province of San Diego County has a series of wide marine terraces, known as mesas, which range from elevations of 50-60 ft at the coast to 800-1,200 ft inland. These mesas are dissected by a number of east-west-flowing streams and rivers that arise in the mountains to the east (6,500 ft at their highest point). The climate in San Diego County is semiarid with a concentration of rainfall in a few major storms, causing soil erosion and loss. All of the major rivers in San Diego County are dammed somewhere along their course before they reach the floodplain, which results in greater control of storm water flows but also in the retention of soils behind the dams and in alterations in the riparian county.

The riparian community of San Diego County was once abundant along water courses flowing out of the mountains before cutting across broad mesas towards the Pacific Ocean. Today, however, there is little contiguous riparian habitat, particularly in the southern part of the county where urbanization pressures have been greatest.

The Santa Margarita is the least disturbed river in San Diego County. Its watershed is about 60 mi long and encompasses an area of about 740 mi^2 extending inland nearly to the San Jacinto Mountains (Zembal, 1984b). The headwaters of its tributaries are at low elevations and some are long distances from the coast. Tributaries of the Santa Margarita River are perennial or intermittent. The river slopes gradually toward the coast and during most of the year is shallow with a flat, sandy bottom (Figure 32). Deeper water in the form of oxbows, small pools, or ponds occurs along lower portions of the river where the floodplain is broad. The upper reach of the river is rockstrewn with limited riffles, a few boulder deposits, and deeper holes.

In a USFWS study of a proposed Santa Margarita Bureau of Reclamation dam project, Zembal (1984b) describes arroyo willow as the most abundant and widespread species. Wild grape and poison oak contribute to the canopy of Fremont cottonwood, western sycamore, and coast live oak. Tree densities are highest in young or short willow woodland (about 16 ft tall). Stands forming between sandbars, adjacent to water channels, and in older woodlands usually consist of sandbar or arroyo willow. Over 100 species make up the low groundcover; however, mulefat, mugwort (Artemisia douglasiana), willow sprouts, Douglas mulefat (Baccharis douglasii), poison oak, wild grape, wild blackberry (Rubus ursinus), sweet clover (Melilotus sp.), scouring rush (Equisetum sp.), stinging nettle (Urtica holosericea), and nut grass (Cyperus sp.) are the most common. One rare and endangered plant, sticky dudleya (Dudleya viscida, CNPS List 1b, J. Smith and York, 1984), and one plant of limited distribution, San Miguel potmint

Figure 32. The Santa Margarita, the least disturbed river in San Diego County, is shallow with a flat sandy bottom.

(Saturejia chandleri, CNPS List 4, J. Smith and York, 1984) grow on vertical canyon walls above tributaries of the Santa Margarita River.

The San Luis Rey River is considered to be one of the least modified and easily restorable rivers in urbanized Southern California, despite the extensive conversion of floodplain riparian habitat to agricultural and other uses (U.S. Army Corps of Engineers, (Corps) 1981). Its watershed covers 565 mi^2. The river originates in the foothills around slopes of Mount Palomar (elevation 6,138 ft) clothed with ponderosa pine and covered with snow in winter. It flows south, then northwesterly through coastal sage scrub and chaparral communities before emptying into Lake Henshaw, a reservoir within the Cleveland National Forest. Lake Henshaw controls about one-third of the San Luis Rey River watershed. West of Lake Henshaw, the San Luis Rey River flows through coastal oak woodlands, chaparral, and coastal sage scrub canyons as it passes through the three Indian reservations of Pala, Rincon, and La Jolla. These native communities are gradually being replaced by citrus and avocado orchards, cattle and horse ranches, golf courses, and resort condominiums. Flow is irregular in this section of the river, varying with the amount of water released at the dams upstream. Farther west and downstream much of the natural San Luis Rey River floodplain has already been turned into truck farms, wheat and barley fields, high-and medium-density residential areas, commercial zones, and industrial parks. Sand-mining operations are frequent along the lower reaches of the river. Before emptying into the Pacific ocean at the city of Oceanside, the San Luis Rey River flows through subclimax riverine riparian and wooded riparian habitats and a series of fresh to brackish water marshes with a saltwater lagoon at the mouth. The mouth of the river at Oceanside was converted into a marina in the early 1960s. Its adjacent wetlands were filled for resort and condominium development and highway construction.

Detailed floristic studies have not been carried out along the San Luis Rey River; however, most of the remnants have been disturbed, and native vegetation has been replaced by non-native plants such as tree tobacco, giant reed, and brome grasses. Freshwater marsh and understory riparian vegetation includes cattail (Typha sp.), bulrush (Scirpus sp.), wild celery (Apium spp.), mulefat, elderberry, poison hemlock (Conium maculatum), and wild grape. Numerous sycamores, estimated to be 50-100 years old, grow beside the river in the floodplain along with associated willow. The San Luis Rey is the southern limit for black cottonwood. An assortment of understory plant assemblages are found, ranging from those associated with freshwater marshes that develop in old oxbow formations to weedy exotics associated with human-altered environments. The rare and endangered sticky dudleya (Dudleya viscida) grows in several locations in the narrows where there are vertical cliff walls near perennial creeks.

The rivers in San Diego County south of the San Luis River have been severely disturbed or degraded so that only remnants of riparian habitat remain on the floodplain, often between a road and a streambed. Some of the better remnant sites are listed in Appendix D. Over the past 50 years disturbances have been from agriculture and sand mining, and in the past 20 years, from rapid urbanization. White alder is found only above 4,000 ft along mountain streams, where it is the most reliable indicator of water. Western azalea (Rhododendron occidentale) occasionally grows above 3,000 ft. Mountain dogwood (Cornus nuttallii) is found on shaded slopes or along streams on Palomar and Cuyamaca mountains (Higgins, 1949). Boxelder was reported by Higgins in 1949 on the La Posta Indian Reservation and in Doane Valley on Palomar Mountain.

Red willow is the most common willow in San Diego County, where it is found growing along streams from the coast into the mountains. Arroyo willow is found in a shrubby form, sometimes as a small tree, from Point Loma east to the Cuyamaca Mountains. Yellow willow or lance-leaf Pacific willow (Salix lasiandra var. lancifolia) is uncommon, growing only as a shrub along San Mateo Creek, in Murphy Canyon, and on Hot Springs Mountain. Goodding's willow grows fairly commonly along streams in Moosa Canyon, San Pasqual, and Lakeside. Graybark willow (Salix hindsiana var.

leucodendroides) grows as a shrub in or close to coastal streams.

Common trees of San Diego County along streambeds or on floodplains include Fremont cottonwood, California sycamore, and coast live oak, which grows to very large size on the moisture-rich floodplain. Elderberry, usually a shrub but sometimes a small tree, is common along streams throughout the county up into the mountains. California walnut is rare, with a specimen reported by Higgins (1949) in Deluz. California bay is not found on the coastal side of San Diego County, but only in relictual stands on the eastern desert slope. Flowering ash, not known in the county prior to 1950, is now reported to grow in Sloan Canyon. Lythrum californicum, uncommon in San Diego County, grows in the Otay River Valley.

A rare plant, San Diego monardella (Monardella linoides subsp. viminea, CNPS List 1b, Smith, 1984), occurs in larger canyons along ephemeral streams that support a flood-disturbance type of vegetation. According to a study for the California Department of Transportation (CALTRANS) by Scheid (1985), small populations can be found growing on coarse, rocky, sandy alluvium on floodplains, on benches cut from the banks of channels, on stabilized sandbars, along the banks of channels and drainages, and even in streambeds in some locations. Though occurring in several physical settings, the locations are all similar in soils and associated vegetation and in the processes leading to the physical development of the sites within the stream system.

Because of extensive disruption along rivers and streams, exotic species are now a major component of San Diego County's riparian habitat. Salt cedar and giant reed thrive and aggressively replace native riparian species in river courses below 1,000 ft. Examples are widespread, but a particularly large invasion of salt cedar can be seen along the San Diego River near Lakeside and of giant reed, off Mission Gorge Road and the Father Serra Trial Road. Efforts in Fallbrook to eliminate giant reed by manual or chemical means have been marginally successful. Castor bean (Ricinus communis), though prevalent, does not have a perennial root as do salt cedar and giant reed, and thus has not become a dominant plant; however, where alluvium has been removed and poorer soils remain, huge thickets of castor bean become established, excluding light and precluding the establishment of native species. German ivy is a less serious pest in San Diego County than farther north in Santa Barbara County but is well established in the side creeks near Chula Vista. Ludwigia uruguayensis has become a dominant water-covering aquatic weed that creeps up and covers streambanks.

3.7 SUMMARY

The modern riparian plant community of Southern California is derived from a southern madro-tertiary xeric element and a northern arcto-tertiary mesic element. Species distribution in this flood-prone habitat is closely tied to the water regime of streams, not only for water supply in a seasonally dry landscape but for a series of events important in plant establishment and succession. Common trees include white alder (a riparian indicator species), willow, cottonwood, and sycamore. The zone closest to the water is most frequently disturbed by storms and is dominated by alder and willow, while cottonwood, sycamore, and oak grow to large sizes on terraces above the river. This part of the riparian community is the most depleted.

Species composition varies somewhat from north to south, coastal to inland, and low to high elevational gradients. There are only a few rare or endangered plants associated with riparian habitat, but the riparian community itself is an endangered community due to the activities of man. In addition, several invasive exotic species are reducing the extent and quality of the small amount of remaining riparian habitat.

CHAPTER 4. THE RIPARIAN COMMUNITY: ANIMALS

4.1 INSECTS

California's insect fauna is so huge, with an estimated 27,000-28,000 species, that there is no State list (Powell and Hogue, 1979). In the Los Angeles basin, there are somewhere between 3,000 and 4,000 species (Hogue, 1974). For comparison, the State has about 500 species of birds (Small, 1974), the largest vertebrate class.

The literature on insects is vast, but much of it is taxonomic; new species continue to be described and families revised. The riparian insect fauna as a group has not been dealt with comprehensively, and only rarely has a scientific paper on the fauna of a Southern California area included insects. One exception was Ingles (1929), who examined the fauna, including insects, of the upper Santa Ana River wash in Los Angeles County at a time when conditions were quite natural along that part of the river. His data were qualitative; he was more interested in distribution than abundance. He defined four plant associations, one of which was riparian (willow/cottonwood), and his list of riparian insects included species from 8 orders: Orthoptera (8 species); Ephemeroptera (1); Odonata (10); Hemiptera (3); Coleoptera (38); Lepidoptera (23); Diptera (24); and Hymenoptera (8). He considered his findings an affirmation of common knowledge concerning the animals of the wash; it is now of historical value as an illustration of what the insect fauna of a lowland river used to be in Southern California.

Recently, lists of insects have been included in some environmental impact reports, along with a discussion of the impact of a proposed project on the fauna. These documents are not readily obtainable, and only one has been cited--a study of the Santa Barbara coastal creeks (Onuf, 1983).

Insects occupy all types of riparian space and include soil dwellers, plant borers, leaf users, and water dwellers. Aquatic insects apparently are adapted only secondarily to life in the water; their ancestral origins are thought to be terrestrial (Usinger, 1956). Many insects are, however, aquatic, and in discussing riparian insects it is convenient to treat aquatic and terrestrial forms separately.

4.1.1 Aquatic Insects

Many riparian insects are aquatic in the nymphal or larval state and as adults are terrestrial or aerial. Adults of these species (e.g., dragonflies, stoneflies, dobsonflies, mosquitoes, and midges) stay close to the water in which they will lay their eggs. Several orders, notably the true bugs and beetles, are aquatic as adults as well, but whereas larvae and nymphs are adapted to obtaining oxygen under water through gills, spiracles, or by cutaneous respiration, adults must breathe air. Ingenious methods, such as carrying an air bubble, have evolved for maintaining an air supply under water (Usinger, 1956). Aquatic nymphs and larvae are often predaceous and are in turn prey for fish. The immature stages usually are substantially different from the adult forms, and many have not yet been identified. Invaluable source books on this subject are Usinger (1956) and Merritt and K.W. Cummins (1978).

The following brief account highlights some of the more important groups associated with riparian habitat in Southern California.

a. Mayflies (Ephemeroptera). The nymphs, called the "cattle" of the aquatic environment for their role in transforming plant into animal tissue (Day, 1956), require weeks or months to develop. Aerial adults live only a few days (Edmunds et al., 1976). The nymphs are a major food source for fish, dragonflies, and birds (Day, 1956). There are about 170 species in California; Powell and Hogue (1979) list three genera that are common in Southern California's coastal streams and lakes: blue-winged duns (Ephemerella), flat-nymphed mayflies (Epeorus), and stilt-legged flies (Callibaetis). One species of Callibaetes, C. pacificus, is ubiquitous in still-water ponds and is an important food source. Mayflies are an excellent indication of environmental quality and have been used by the U.S. Environmental Protection Agency for this purpose (C. Nagano, Natural History Museum, Los Angeles County; pers. comm.).

b. Damselflies and dragonflies (Odonata). The nymphs (also called naiads) are predaceous water dwellers, eating immature insects, crustaceans, tadpoles, fish, and young salamanders (Essig, 1926). They do not usually chase their prey but lie in wait for it (Needham and Westfall, 1955). They serve as food for fish, birds, and frogs (Smith and Pritchard, 1956). Adults feed on mosquitoes and gnats (Powell and Hogue, 1979). Widespread wherever there is permanent, clean freshwater, the adults are handsome insects, interesting to watch and much valued by collectors (Figure 33). There are about 100 species of this order in California (Powell and Hogue, 1979). The commonest dragonflies are those in the Libellulidae or skimmer family; the commonest damsel flies are the bluets (F. Coenagrionidae).

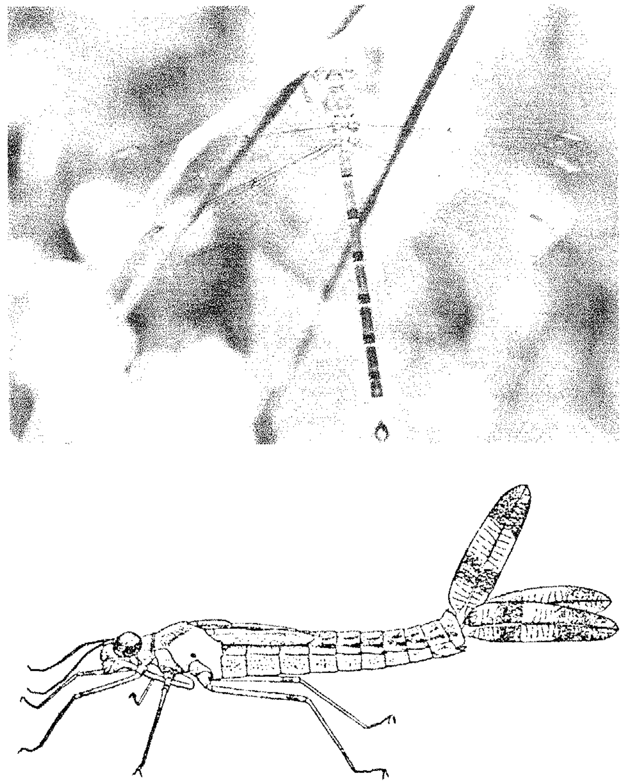


Figure 33. A predaceous nymph and adult of the California spreadwing, a damselfly common in freshwater bogs. Photo courtesy of Charles Hogue.

c. Stoneflies (Plecoptera). Stonefly nymphs require moving water and are associated mostly with mountain streams, where they are a major food source for trout (Jewett, 1956). Winter stoneflies (F. Capniidae) mature early in the year and are a food source when other insects are unavailable (Powell and Hogue, 1979). There are about 100 species of stoneflies in California, with at least 3 important genera in Southern California: Nemoura, Pteronarcys, and Acroneuria.

d. Crickets (Orthoptera). Orthopterans are not usually associated with water, but the pygmy mole crickets (Tridactylus spp.) are an exception. They are fossorial, burrowing in loose soil bordering water, and swim well (La Rivers, 1956). Their role in riparian ecology has not been well researched.

e. True bugs (Hemiptera). Water bugs generally overwinter as adults and lay eggs in the spring. The nymphs hatch and develop in summer, become adults in late summer, and continue the annual cycle (Usinger, 1956). In many families all stages are aquatic; a few have fossorial adults. Most water bugs can fly but are more at home in water.

There are several families in Southern California. The water boatmen (Corixidae) feed on algae, diatoms, rotifers, and mosquito larvae and are themselves preferred food for many fish (Usinger, 1956). Backswimmers (Notonectidae) swim upside down and prey on mosquitoes and small fish. They can inflict a painful bite (Usinger, 1956). Water striders (Gerridae) prey on organisms that fall into the water. The most common species in Southern California is Gerris remigis (Powell and Hogue, 1979). Giant water boatmen (Belostomatidae) occur in streams and ponds and hunt from under water. Among the largest insects, they prey on other insects, tadpoles, fish, and even snakes. Females of some genera lay eggs on the back of the male, where they are carried until they hatch (Usinger, 1956). One species, the electric light bug (Lethocerus americanus), may no longer exist in Southern California; it was dependent on freshwater ponds. Common species in Southern California are the toe biters (Abedus indentatus) and Belastoma flumineum. All giant water boatmen can inflict a painful bite. The creeping waterbugs (Naucoridae) are inhabitants of slow streams with pebbly bottoms. They are highly predaceous and eat water boatmen, mosquito larvae, and mollusks. They also can inflict a painful bite. The common Southern California species is Ambrysus occidentalis (Powell and Hogue, 1979).

f. Dobsonflies (Neuroptera). Adults deposit egg masses on objects overhanging water. The larvae are fully aquatic, have powerful mandibles, and are highly predaceous. Mature larvae burrow into banks above water and pupate (Powell and Hogue, 1979). Neohermes filicornis larvae are important fish food.

g. Caddisflies (Trichoptera). The aquatic larvae of many species form cases of silk with pebbles and plant fragments attached, are stationary, and feed on plants. They are food for fish and have often been used as bait. There are about 300 species in 14 families in California (Powell and Hogue, 1979). The family Limnephilidae dominates California's Tricopterans, with more than 40 species described. The genus Limnephilus is widespread in the foothills and mountains and is a major food for trout (C. Hogue, pers. comm.).

h. Moths (Lepidoptera). Only a few moths have adapted to aquatic habitat, mostly in the subfamily Nymphulini. In one genus, Parargyractis, all stages except adults are aquatic. The larvae are rock-dwellers and construct silken tents from which they feed on algae and diatoms (Lange, 1956).

i. Beetles (Coleoptera). Water beetles, like the water bugs, include partially and fully aquatic species. Adults as well as eggs and larvae or nymphs are often aquatic; only the pupal stage is terrestrial. Adults carry their air supply with them in the form of a bubble or a sheet of air held by fine hairs (Leech and Chandler, 1956). The larvae are generally predaceous, as are many adults (with some exceptions, such as scavenger beetles). Many families are represented in Southern California. A few of the more common ones are listed below.

(1) Predaceous diving beetles (Dytiscidae). Common from sea level to 4,000 m in many freshwater situations; the larvae are predaceous and cannibalistic, feeding on larvae and adults of other insects, worms, leeches, snails, tadpoles, and small fish. Adults are prey for all classes of vertebrates; among birds, they are particularly sought by ducks and waders (Leech and Chandler, 1956).

(2) Whirligig beetles (Gyrinidae). These beetles can dive and fly but are most at home on the surface of the water, which is their foraging niche (Figure 34). Found in a

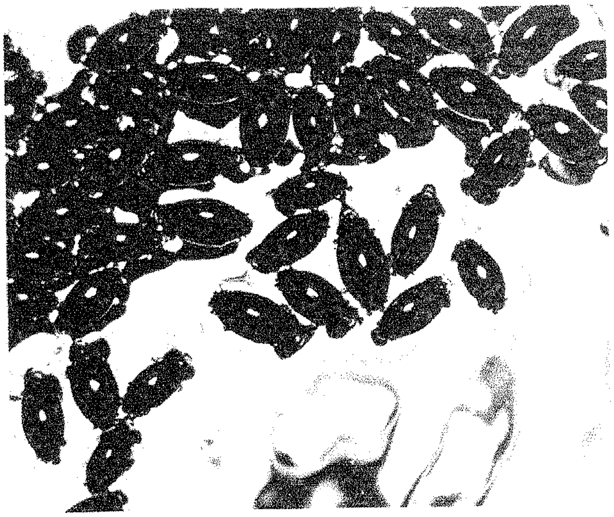


Figure 34. Whirligig beetles (Dineutus sp.) on the surface of an eddy in a stream. Photo courtesy of Charles Hogue.

variety of freshwater habitats, the larvae are predaceous and cannibalistic (Leech and Chandler, 1956).

(3) Water scavenger beetles (Hydrophilidae). Most species of water beetles are in this family. They are generally vegetarian and move more slowly than the predaceous beetles. Both adults and larvae are an important food source for fish and aquatic birds (Leech and Chandler, 1956).

(4) Water pennies (Psephenidae). The larvae are round and flat, with the body margins expanded to cover the head and legs (Powell and Hogue, 1979). They cling to the surfaces of rocks like limpets. Adults are terrestrial and are not easily seen. Water pennies are found throughout California in clear, fast streams, usually below 1,600 m (Leech and Chandler, 1956).

j. Flies, gnats, midges, mosquitoes (Diptera). Approximately half of this large and diverse order are aquatic in the early stages. The adults are aerial or terrestrial. Dipterans perform many ecological functions; they prey on other invertebrates, serve as food for birds, amphibians, and fish, and are useful indicators of environmental quality. The biting habit of some flies is highly irritating to humans, and several species transmit serious mammalian diseases.

(1) Net-winged midges (Blephariceridae). Larvae are found in swift-water streams from 40 to 4,000 m. They are vegetarian and, as they are sensitive to pollution, are indicators of the health of the stream. One species, Agathon comstocki, is an important food of the dipper (Cinclus mexicanus). This family is under study in the San Gabriel Mountains.

(2) Craneflies (Tipulidae). One species, the giant cranefly (Holorusia rubiginosa), has a huge, semiaquatic larva that is a major food source for birds.

(3) Mosquitoes (Cuculidae). Both larvae and pupae are aquatic (Wirth and Stone, 1956) and generally vegetarian (Essig, 1926). They are ubiquitous in ponds and many stillwater situations, as well as in streams.

(4) Midges (Chironomidae). Midges in all stages of metamorphosis are a prime source of food for fish (Wirth and Stone, 1956). Larval feeding habitats vary; some are predaceous, while others feed on detritus. There are about 200 species in California (Powell and Hogue, 1979) and, in the familiar swarms that occur in spring and summer, the number of individuals can be astronomical. Chironomids have been used as indicators of environmental quality.

4.1.2 Terrestrial Insects

Terrestrial insects range from tiny primitive wingless soil-reducing springtails to large highly evolved flying social ants. There are probably more species of beetles than any other order in terrestrial riparian habitat, which is not surprising since Coleoptera is the largest order in the animal kingdom (Powell and Hogue, 1979).

Certain plants host an astonishing variety of insects, both larvae and adults. Some of these host/insect relationships are noted below; more complete listings are found in indexes of host plants in Essig (1926), Tietz (1972), and Emmel and Emmel (1973). The more important orders are briefly described below.

a. Springtails, etc. (Protura, Diplura, Collembola). These primitive insects are almost microscopic. They do not undergo metamorphosis; many lack eyes and antennae. They are vegetarian and their habitat is moist soil, leaf litter, and rotting wood. There are only a few species of Proturans and Diplurans in California, but about 150 Collembola (Powell and Hogue, 1979). They are not well studied, but are known to be important soil reducers.

b. Bird lice (Mallophaga). These ectoparasites feed on hair, feathers, and dried blood around wounds on the host. They can cause great discomfort and even death if the infestation is severe. Eggs are deposited on the host. Many riparian bird species are afflicted by Mallophagans. A list of host species is given by Emerson (1964).

c. True bugs (Hemiptera). Three species in different families are common plant bugs in riparian habitat: western boxelder bug (<u>Leptocoris rubrolineatus</u>) feeds on the foliage of boxelder and maple (Powell and Hogue, 1979); giant willow aphid (<u>Tuberolachnus salignus</u>) feeds in large, compact colonies on the trunks and branches of willows (Essig, 1926); and the oak treehopper (<u>Platycotis vittata</u>) inserts its eggs in twigs on oaks throughout California and occasionally on other broadleaved trees (Essig, 1926).

d. Flies, gnats, midges, mosquitoes (Diptera). As noted previously, about half the Dipterans have aquatic larvae, and adults usually stay close to water. Some, such as mosquitoes, horseflies, and deerflies, are severe nuisances to humans. Several families with aquatic larvae whose adults play important roles in riparian terrestrial ecology are:

(1) Moth flies (Psychodidae). The lance-winged moth fly, <u>Maruina lanceolata</u>, is common along streams, crawling on boulders and feeding on diatomaceous and algal films on the substrate (Powell and Hogue, 1979).

(2) Mosquitoes (Cuculidae). This is probably the most thoroughly studied family of Diptera because of the diseases transmitted by mosquitoes and their general role as nuisances. Only the females bite. There are 47 known species in California (Powell and Hogue, 1979).

(3) Horse flies, deer flies (Tabanidae). There are about 75 species in California (Powell and Hogue, 1979). Most are strong fliers and the females are wicked biters; the males are mostly nectar sippers (Cole, 1969). Some species are suspected of transmitting diseases, including tularemia and anthrax. The common horse fly in California is <u>Tabanus punctifer</u>; the females feed on the blood of large mammals but rarely bite man (Powell and Hogue, 1979).

Other Dipterans are riparian without being aquatic. Many are associated with damp soil and riparian trees such as willows and oaks. Eggs are laid in moist soil, leaf mold, or under bark, and the larvae are generally vegetarian. Some examples are:

(4) Craneflies (Tipulidae). The common craneflies of the genus <u>Tipula</u> are active in moist woodlands and are nectar-feeders. The larvae are found in rich, damp soil and feed on roots and decaying vegetation (Cole, 1969).

(5) March flies (Bibionidae). Larvae feed on plant roots and decaying vegetation; adults swarm in the spring. The adults have an affinity for blossoms and may be of value as pollinators (Cole, 1969).

(6) Pomace flies (Drosophilidae). The trail gnat (Amiota picta) is a small and extremely irritating pest to hikers. Adults are found near streams and are attracted to human eyes. Larvae are unknown (Powell and Hogue, 1979).

e. Moths, butterflies (Lepidoptera). The eggs are laid on or near food, and the larvae are largely vegetarian, feeding on a wide variety of hosts (Tietz, 1962). Mature moths and butterflies are generally nectar-feeders and are prime pollinators for many flowering plants. Moths are generally nocturnal, while butterflies are active during the day (Powell and Hogue, 1979). The larvae are seldom damaging to their hosts; the list of caterpillars that feed on riparian trees and shrubs in Southern California is long and includes species from many families (Figure 35). Table 7 lists characteristic riparian moths and their host plants. The host tree harbors the larval stage unless otherwise noted. Table 8 lists riparian butterflies (larvae) and their host plants.

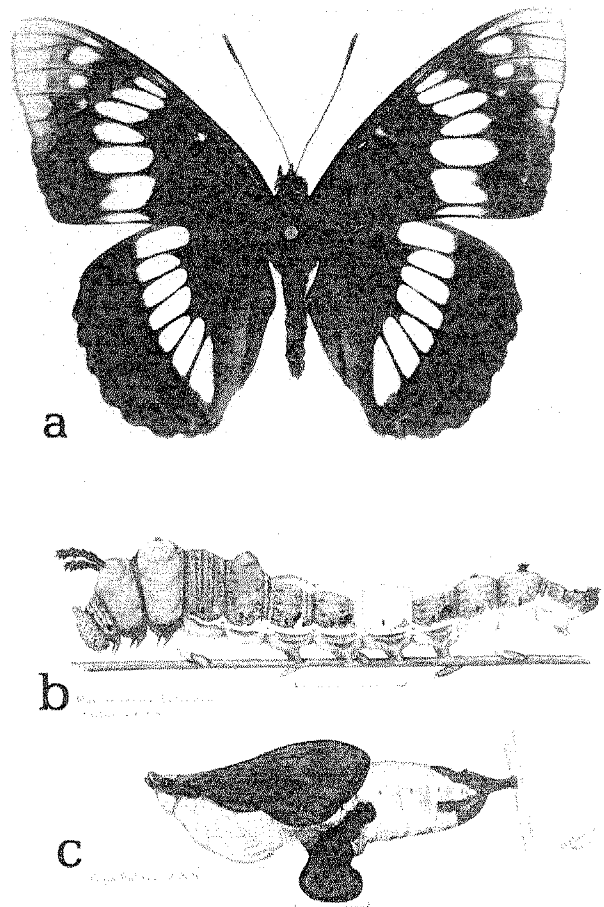


Figure 35. Lorquin's admiral (Limenitis lorquini) larva, pupa, and adult. The larvae feed on willows and cottonwoods. Photo courtesy of Charles Hogue.

f. Beetles (Coleoptera). Terrestrial riparian beetles include ground dwellers (Cicindelidae, Carabidae), borers (Cerambycidae, Curculionidae), leaf miners (Chrysomelidae), predators on other insects (F. Coccinellidae), and many more. Only the briefest coverage is possible here.

(1) Tiger beetles (Cicindelidae). The fast-moving adults inhabit sandy or gravelly shores of lakes and streams (Essig, 1926). Larvae live in burrows in the same habitat (Powell and Hogue, 1979). The Oregon tiger beetle, Cicindela oregona, is a common Southern California species (Powell and Hogue, 1979). The greenest tiger beetle, C. tranquebarica viridissima, is being considered for listing as an endangered species (Zembal, 1984a). It inhibits the Santa Ana River drainage (C. Nagano, pers. comm).

(2) Predaceous ground beetles (Carabidae). The eggs of these beetles are usually laid on the ground. Both larvae and adults are active predators, the adults mostly at night (Essig, 1926). This is a huge and diverse family with 800 species in California. Tule beetles (Agonum spp.) are common

Table 7. Moths (larvae) and their riparian host plants (from Powell and Hogue, 1979).

Common name	Scientific name	Host tree
Locust clearwing	Paranthrene robiniae	Willow, sycamore, cottonwood
Carpetworm	Prionoxystus robiniae	Alder, cottonwood, live oak, maple
California oak moth	Phryganidia californica	Live oak
Willow nestmaker	Icthyura apicalis	Willow
Annaphila	Annaphila spp.	Willow (adults)
Yellow-spotted tiger moth	Halisidota maculata	Willow, other broad-leaved trees
Nevada buck moth	Hemileuca nevadensis	Willow
Eyed sphinx	Smerinthus cerisyi	Willow

Table 8. Butterflies (larvae) and their riparian host plants (from Emmel and Emmel, 1973).

Common name	Scientific name	Host plant or tree
Western tiger swallowtail	Papilio rutulus	Sycamore, willow
Lorquin's admiral	Limentis lorquini	Willow
Satyr anglewing	Polygonia satyrus	Creek nettle Urtica holosericea
California sister	Adelpha bredowi	Live oak
Mourning cloak	Nymphalis antiopa	Willow, alder, cottonwood
Sylvan hairstreak	Satyrium sylvinus	Dudlyea lanceolata

in marshy places in Southern California; the bombardier beetle, Brachinus tschernikhi, inhabits rocky margins of lakes and streams (Powell and Hogue, 1979), as do the false bombardiers, Chlaenius spp. (Hogue, 1974).

(3) Ladybirds (Coccinellidae). Both larvae and adults of most species eat aphids and other scale insects and are considered beneficial (Essig, 1926). The convergent ladybird beetle, Hippodamia convergens, is a common species in Southern California; great masses of these beetles hibernate in coastal canyons, then migrate downstream to the valleys in early spring to feed on aphids (Powell and Hogue, 1979).

(4) Longhorn beetles (Cerambycidae). Larvae bore into wood of dead and dying trees, and into the roots of living trees and shrubs. Adults commonly visit flowers (Essig, 1926). The branded alder borer, Rosalia funebris, attacks alder and California laurel; the California prionus, Prionus californica, bores into oaks (Powell and Hogue, 1979).

(5) Weevils (Curculionidae). Both larvae and adults are vegetarian and are extremely destructive to their hosts. Females bore into tree trunks, twigs, and flowers to lay eggs, and the larvae hatch in their food supply. This huge family has more than 1,000 species in California, attacking many plants (Powell and Hogue, 1979). In riparian habitat the rose curculio, Rhynchites bicolor, commonly infests wild roses and blackberries along streams.

(6) Leaf beetles (Chrysomelidae). Both adults and larvae feed on leaves and are very destructive to their hosts. In riparian habitat there are numerous species; some generalists, others specialists. Members of at least four genera (Lina, Disonycha, Galerncella, Pachybrachys) feed primarily on willow leaves; several species of Lina have a predeliction for riparian trees, including cottonwood, willow, and aspen (Essig, 1926).

f. Ants, wasps, bees (Hymenoptera). These highly evolved, often social insects are not particularly associated with riparian habitat, but there are some exceptions.

(1) Sawflies (Tenthredinidae). Females usually cut slits in young shoots or leaves and insert their eggs; the larvae feed on the leaves. In Southern California the green willow sawflies, Rhogogaster spp., are common (Powell and Hogue, 1979). Some sawflies cause galls, e.g., the willow leafgall sawfly, Euura pacifica. Larvae of this species are parasitized by a braconid wasp (Essig, 1926).

(2) Gall wasps (Cynipidae). The large familiar oak gall is caused by the California oak gall wasp, Andricus californicus, which is in turn parasitized by the oak gall chalcid, Torymus californicus (Powell and Hogue, 1979).

4.1.3 Role of Insects in Riparian Ecology

Ecologically, riparian insects are prey, predators, pollinators, water purifiers, grazers, soil reducers, mosquito-control agents, and more. As a source of food for other animals their importance cannot be overstated; they feed all classes of vertebrates, as well as other insects. Birds in particular depend on them; the great blooms of insects in late spring and summer provide food for the migrants that come to breed (Pequegnat, 1951), and resident birds use this supplemental food source to raise their young (Rosenberg et al. 1982). As predators, riparian insects act as regulators of vegetative growth, a role for which they are not usually accorded recognition. Of prime importance is their role in pollination. Bees are the best known of the pollinators; solitary bees (Grigarick, 1968) and bumble bees (Thorp et al., 1983) are major pollinators of native California flowering plants. The literature on insect pollination is large but diffuse, and culling information on riparian plants is difficult.

The niche occupied by any insect is dictated by its food and reproductive requirements, and the two are often linked. Eggs are laid where the larvae will feed when they hatch. Brucs (1946) distinguished four types of insects in terms of their food habitat: (1) those that feed on living plants, which includes about half the known species; (2) predaceous insects that consume living animals; (3) saprophagous insects whose food is dead/decaying animal matter; and (4) parasites, both internal and external.

In occupying these niches, insects play a vital role in the ecological balance of their habitats. Not only are they actively eating, and thus regulating, the plants and animals with which they are associated, but they are serving as food for others farther up the food chain.

There are no Southern California riparian insects listed as endangered or threatened. The recent inclusion of the greenest tiger beetle in a group to be considered for listing (Zembal, 1984a) is the first ripple in what may become a large wave. This beetle is restricted to the Santa Ana River basin in Orange, Riverside, and San Bernardino Counties where habitat alteration, particularly stream channelization, has sharply reduced its range (C. Nagano, pers. comm.).

The impact of streambed alteration on aquatic insects has received little attention and deserves more. One such study on the San Gabriel River showed that water beetles were extirpated from the cement-lined portions of the river and could be found only in a few places along its course on the coastal plain (Perkins, 1976). The ecological implications were not discussed and probably not known.

In summary, both in numbers of species and numbers of individuals, insects are the major fauna in riparian habitat. They occupy every ecological niche and serve as both predators (mostly on other insects) and prey (for all the vertebrate classes). Many are aquatic in one or more of their developmental stages; some are totally aquatic. Terrestrial insects in riparian habitat include soil-dwellers, flower-sippers, leaf-eaters, bark-borers, bird parasites, and others. The life cycles of most species are poorly known, and only the most general information is available for many families. A monograph on the riparian insect fauna would be of great value.

4.2 FISH

The streams and lakes of Southern California have never supported a very diversified fish population. Coastal streams have always been intermittent, their flows dependent on good winter rainfall. Near the coast the smaller streams are often dry for several months of the year; as fish habitat, they have never been very hospitable. There are eight families of native freshwater fish, each represented by one or two species. Only four species of subspecies are endemic (see checklist below); they were found originally in the four rivers of the Los Angeles and Ventura Basins (Santa Ana, San Gabriel, Los Angeles, Santa Clara). According to Hubbs, these rivers used to interconnect in their headwaters during years of high water (Moyle, 1976). The following annotated checklist covers all of the native freshwater fish (nomenclature follows American Fisheries Society, 1980).

4.2.1 Native Fish

a. Petromyzonidae: lampreys. Pacific lamprey, Lampretra tridentata. The most primitive of its genus, this parasitic species is a wide-ranging, anadromous fish, found most from Monterey north (Moyle, 1976). Despite predaceous habits, it does not appear to affect populations of other local fish (Moyle, 1976), as does the introduced lamprey, Pteromyzon marinus, of the Great Lakes. Formerly in the Santa Ana River, it has been reported recently only from the Santa Clara River in Ventura County (C. Swift, Natural History Museum, Los Angeles County; pers. comm.).

b. Salmonidae: trout and salmon. Rainbow trout, Salmo gairdneri (Figure 36). This trout is native to coastal streams from the Los Angeles River

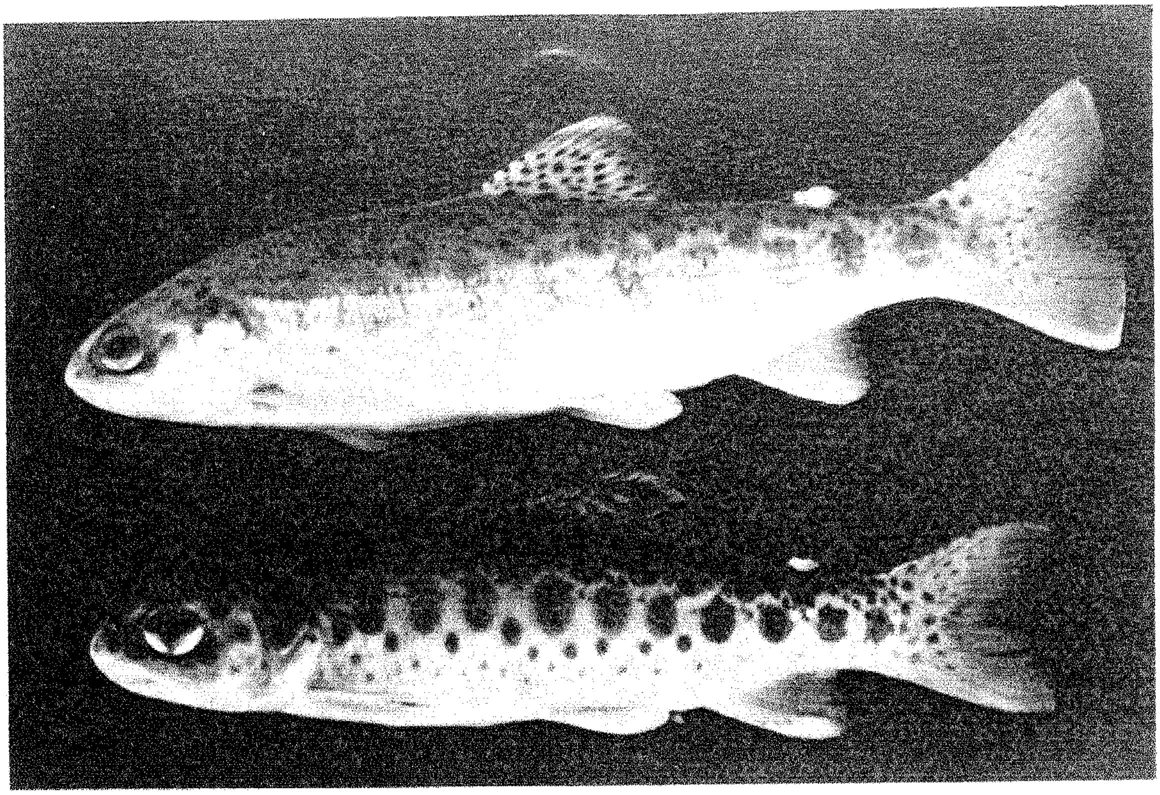


Figure 36. Rainbow trout (Salmo gairdneri) native to Southern California coastal streams. Top specimen from Malibu Creek, bottom from the San Gabriel River. Photo courtesy of Camm Swift.

basin north. One subspecies, S. g. gairdneri is anadromous. These "steelhead" are generally larger than the all-year residents but are otherwise indistinguishable when they occur together (Moyle, 1976); in Southern California they are still present in the Ventura River, Santa Clara River, and Malibu Creek (C. Swift, pers. comm.). The resident rainbow trout has been supplemented in many Southern California streams by hatchery-raised stock. Recently, there has been concern among fish biologists about the loss, through hybridization, of the distinctive character of local populations (Moyle, 1976).

c. Cyprinidae: minnows.

(1) Arroyo chub, Gila orcutti. A native of Southern California, this small endemic once inhabited coastal and mountain streams from Malibu Creek to the San Luis Rey River. It was introduced successfully in the Santa Clara, Ventura, and Santa Ynez Rivers and Gaviota Creek (Miller, 1968). Now very hard to find, it is still probably in the mountain creeks, and was recently found in the Santa Margarita River (Zembal, 1984b). Small to moderate-sized streams with some flow are the preferred habitat. The chub is usually mid-water or benthic in the stream and feeds on aquatic insects, snails, and some algae (Lee, 1980). Tui chubs (G. bicolor) are nearly indistinguishable from G. orcutti. They have been widely introduced along with trout. Subsequent hybridization between arroyo and tui chubs may swamp entirely the G. orcutti gene pool (A. Schoenherr,

California State University (Fullerton); pers. comm.).

(2) Speckled dace, Rhinichthys osculus. This endemic fish is found throughout California, but not in most coastal streams (Moyle, 1976). There is a real hiatus in its distribution along the coast; it is native only to the Santa Ana River system and to San Luis Obispo Creek (Miller, 1968). This is a riffle fish and a bottom browser, feeding on small invertebrates and plants. It is found mainly in cool, fast-moving streams with rocky bottoms, but sometimes in other types of freshwater habitats in the western United States (Hubbs et al., 1974).

d. Catostomatidae: suckers. Santa Ana sucker, Catostomus santaanae. A small endemic of limited range, it is known only from the Los Angeles, San Gabriel, and Santa Ana Rivers and from the Santa Clara River, where it was probably introduced (Miller, 1968). A bottom-browser that feeds on small invertebrates and plants, it prefers clear, cool, rocky and gravelly streams with a moderate gradient (Lee et al., 1980). The life history of this fish was studied by Greenfield and co-workers (1970 in the Santa Clara River, where it was then abundant.

e. Cyprinodontidae: pupfish, killifish. California killifish, Fundulus parvipinnis. In shallow coastal waters from Monterey to southern Baja California, Mexico, these fish are still plentiful. Formerly found in freshwater streams in Southern California, such as San Juan Creek in Orange County in the 1940s (Moyle, 1976), its current status as a freshwater fish is uncertain. Recent efforts to find a relict population in San Juan Creek were unsuccessful (A. Schoenherr, pers. comm.).

f. Gasterostidae: sticklebacks. Unarmored threespine stickleback, Gasterosteus aculeatus williamsoni (Figure 37). This small endemic fish was once abundant in the rivers of the Los Angeles and Ventura basins (Miller, 1960); it is now found only only in the Soledad Canyon Section of the Santa Clara River and a few of its small tributaries. A natural river with clear, slow flow is its essential habitat; the rivers in the Los Angeles basin are no longer suitable. There are only four known populations in the upper Santa Clara River. It was listed in 1970 as an endangered species by the USFWS and in 1972 by the California Department of Fish and Game. There are introduced populations of the partially armored stickleback, G. a. microcephalus, in San Juan Creek in Casper's Park and in the San Joaquin Marsh on San Diego Creek, and care must be taken to prevent hybridization.

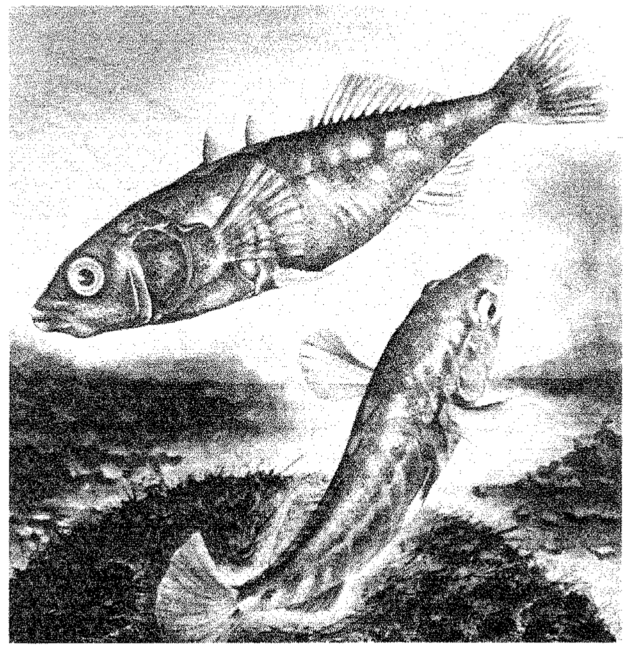


Figure 37. Unarmored three-spine stickleback (Gasterosteus aculeatus williamsoni), an endangered fish of the Southern California coastal streams. Photo courtesy of Camm Swift.

g. Gobiidae: gobies. Tidewater goby, Eucyclogobius newberryi. Adapted to both fresh- and saltwater, the goby's habitat is coastal lagoons and the lower reaches of streams from Humboldt

County to San Diego County. It is no longer found in most coastal streams and is scarce in lagoons (C. Swift, pers. comm.). Gobies spawn in coarse sand on stream bottoms and in lagoons, preferring slow-moving areas of streams. Their status is under investigation by Swift, and appears to be desperate. The tidewater goby is a likely candidate for listing as an endangered species.

h. Cottidae: sculpins.

(1) Pacific staghorn sculpin, Leptocottus armatus, and prickly sculpin, Cottus asper. These common bottom fishes are found in both salt- and freshwater; both appear to be adaptable to alterations in their environment and are not in apparent trouble. The staghorn sculpin is distributed from Alaska to San Quintin Bay, Baja California, and inhabits bays and inlets in the southern part of its range. It is common in freshwater close to the coast (Moyle, 1967). The prickly sculpin's southern limit is the Ventura River (Lee, 1980); it is found well inland in lakes and reservoirs as well as streams.

(2) The striped mullet, Mugil cephalus, is a marine species that often moves up into the lower reaches of streams in Southern California (Moyle, 1976). Its use of freshwater in this area is considered casual.

4.2.2 Introduced Fish

A minimum of 28 species of non-native fish have become established in Southern California's coastal streams. Moyle (1976) lists eight major reasons for their introduction: to improve fishing, to provide forage for game fishes, to provide bait, to use for insect and weed control, as pets, for aquaculture, and by accident. Most of the deliberate introductions were game and food fish such as bass, bullhead, and trout. The impact of these introductions is difficult to assess; competition between two species for a food supply and the elimination of a native species by an introduced predator are extremely difficult to document. Introductions have often been concurrent with radical alterations of the waterways, and multiple variables have complicated scientific analysis. There is one certainty, however: introduced species have radically changed the nature of our fish fauna and are now the most abundant fishes in most of the State's inland waters (Moyle, 1976). In terms of species, introduced fish far outnumber the 10 native species in Southern California. In addition to the 28 species listed by Moyle (1976), there are probably 10 more that are well established in Southern California (A. Schoenherr, pers. comm.).

The status of native fishes in the coastal streams is catastrophic. Of the 10 species that once thrived, only the 2 sculpin are apparently sustaining normal populations. The major reason for this alarming situation is destruction of habitat. Extensive damming and channelizing of coastal waterways and mining and other silt-producing operations have deprived fish, particularly stream fish, of most of their habitat. The few rivers that are still intact or have intact sections should be examined for possible relict populations, particularly the Santa Margarita River, the upper reaches of the San Luis Rey River, and the mountain tributaries of the Santa Ana, San Gabriel, and Los Angeles Rivers.

4.3 AMPHIBIANS AND REPTILES

The characteristic herpetofauna of the San Gabriel Mountains was described by Schoenherr (1976); the description is generally applicable to the other mountain ranges in coastal Southern California. Schoenherr delineated nine plant communities, and for riparian woodland he listed the following as obligate amphibians (nomenclature follows Collins et al., 1978): California treefrog, Hyla cadaverina; red-legged frog, Rana aurora; foothill yellow-legged frog, Rana boylei; mountain yellow-legged frog, Rana muscosa; and the introduced bullfrog, Rana catesbeiana. The red-legged frog and the mountain yellow-legged frog are not widely distributed; the latter occurs only in the San Gabriel Mountains and very locally elsewhere in Southern California (Stebbins, 1966). Species commonly found in both riparian and other habitats were the California newt, *Taricha torosa*; ensatina, *Ensatina eschscholtzi*; California slender salamander, *Batrachoceps negriventis*--a recently revised taxon (Yanev, 1980); western toad, *Bufo boreas*; southwestern toad, *Bufo microscaphus*; Pacific treefrog, *Hyla regilla*; and western spadefoot, *Scaphiorus hammondi*.

The obligate reptiles were the western pond turtle, *Clemmys marmorata*, and the western aquatic garter snake, *Thamnophis couchi*. Nonobligate reptiles were the collared lizard, *Crotaphytus collaris*; western fence lizard, *Sceloporus occidentalis*; sideblotched lizard, *Uta stansburiana*; western skink, *Eumeces skiltonianus*; Gilbert's skink, *Eumeces gilberti*; western whiptail, *Cnemidophorus tigris*; southern alligator lizard, *Gerrhonotus multicarinatus*; California legless lizard, *Anniella pulchara*; ringneck snake, *Diadophus trivirgata*; California mountain king snake, *Lampropeltis zonata*; striped racer, *Masticophis lateralis*; gopher snake, *Pituophis melanoleucus*; and western rattlesnake, *Crotalus viridis*.

Many of these species are still fairly common; mountain streams have not generally been subjected to alterations as severe as those affecting valley streams. In the lowlands, a few natural river courses still support healthy communities of amphibians and reptiles, but such habitat is exceedingly rare. The Santa Margarita River is one such place, and in 1982 the following amphibians were found there in riparian habitat: California slender salamander, California newt, western toad, southwestern toad, California treefrog, Pacific treefrog, western spade-foot, red-legged frog, and bullfrog. Reptiles included the western pond turtle, western fence lizard, western skink, orange-throated whiptail (*Cnemidophorus hyperythrus*), western whiptail, rosy boa (*Lichanura trivirgata*), aquatic garter snake, western blind snake (*Leptotyphlops humilis*), and western rattlesnake (Zembal, 1984b). The orange-throated whiptail has a restricted range; its northern limits are in Southern Orange County (Stebbins, 1966).

Among the amphibians, the salamanders and tree frogs seem to be faring better than the true frogs. Salamanders are not restricted to the riparian community; they are adaptable to woodlands, gardens, and other habitats and thus have a range of choice. In general, amphibians dependent on riparian habitat are disappearing. Oddly enough, tree frog populations are fairly stable, even though the canyon treefrog is considered strictly riparian.

The red-legged frog is becoming increasingly scarce in Santa Barbara County (McKeown, 1974), which was probably its last lowland stronghold in Southern California. Indiscriminate collecting and heavy recreational use of streams are blamed for its decline, along with habitat destruction. It is fully protected (CFG Commission Regulations, 1983, Title 14) and can be taken only by special permit. The foothill yellow-legged frog has mysteriously disappeared from Southern California in recent years. Formerly widespread and fairly common in the Southern California coastal mountains, it has not been seen since 1975 despite repeated searches (Sweet, 1983). Damage to montane stream habitat by overuse, particularly from off-road vehicles, coupled with the coincidence of two major floods in the winter of 1969, are credited with causing the apparent extinction of this species (A. Schoenherr and S. Sweet, Natural History Museum, Los Angeles County; pers. comm.).

The most threatened reptile is the western pond turtle. At home in streams and large rivers as well as lakes and ponds, this turtle is also well adapted to Southern California's summer-dry, winter-wet Mediterranean climate (Bury, 1972). It was collected indiscriminately for the pet trade and by individuals until State law limited taking to two per person (CFG Commission Regulations, 1983, Title 14). During the 1970s, the turtle's status was under investigation by the California Department of Fish and Game as a possible candidate for listing. Passage of the above law has alleviated some of the pressure, and the turtle is reportedly doing well in Santa Barbara County, although there is no information from other parts of Southern California.

Two introduced species appear to be threatening some of the native species. The bullfrog is now widespread in California, and its voracious appetite includes a taste for other frogs. In Santa Barbara County, efforts are being made to keep the bullfrog out of the Santa Ynez River drainage and Cuyama Valley in order to protect the red-legged frog. A more recent introduction is the African clawed frog, Xenopus laevis which is spreading rapidly and is now in all the flood-control channels in Los Angeles and Orange counties (G. St. Amant, California Department of Fish and Game, Region 5, Long Beach; pers. comm.). The Fish and Game Department has initiated a control program in Agua Dulce Canyon to keep this voracious predator out of the habitat of the unarmored threespine stickleback, an endangered fish. Other than that, the frog is not under investigation, and its impacts and the extent of its spread are unknown.

An interesting aspect of the relationship between reptiles and riparian habitat is the use of stream washes by several lizards to expand their ranges. The collared lizard has moved across the divide from the desert side to the Pacific slope of the San Gabriel Mountains and as locally abundant in Cajon Wash, Lytle Creek, and the upper east fork of the San Gabriel River in the 1970s (Schoenherr, 1976). The zebra-tailed lizard (Callisaurus draconoides), desert horned lizard (Phrynosoma platyrhinos), leopard lizard (Crotaphytus wislizenii), and coachwhip (Masticophis flagellum) apparently have also moved via stream channels in Cajon and Soledad canyons and are now in the San Jacinto River drainage (Schoenherr, 1976; Stebbins, 1966).

The following annotated list covers only amphibians and reptiles that are dependent upon, or prefer, riparian habitat:

a. California newt, Taricha torosa. Common in pools and slow-moving streams from near sea level to 2000 meters (Stebbins, 1966), the California newt is generally restricted to the low parts of streams, even though lower reaches are often dry in summer, since high streams are too steep and fast (Pequegnat, 1951). It has been collected in oak woodland in the San Gabriel Mountains as well as in streamside habitat. There is no indication that populations are in any stress (Schoenherr, 1976).

b. Ensatina, Ensatina eschscholtzi. Ensatinas are found in a variety of habitats in the San Gabriel Mountains and appear well adapted to oak woodland and chapparal as well as to riparian habitat (Schoenherr, 1976). Uncommon in the Santa Ana Mountains (Pequegnat, 1951), they have been recorded from only a few locations in San Diego County (Sloan, 1964).

c. California slender salamander, Batrachoceps negriventis. Common to abundant throughout coastal Southern California, this salamander is moisture-loving and is found in leaf litter, under rocks, along streams, in oak woodland, and has adapted well to gardens (McKeown, 1974).

d. Arboreal salamander, Aneides lugubris. Also called the oak salamander because of its affinity for oak woodland, the arboreal salamander is widespread throughout coastal Southern California wherever there is appropriate habitat. It has been reported as locally common (Pequegnat, 1951; Schoenherr, 1976) except in San Diego County, where it was not easily found (Sloan, 1964).

e. California canyon treefrog, Hyla cadavarina (Figure 38). Found in the San Gabriel Mountains, the California treefrog is restricted to riparian habitat and is most abundant in fast streams from 460 to 1,000 m (Schoenherr 1976). In the Santa Ana Mountains its lower limit is about where the streams dry up in summer (Pequegnat, 1951). It has been reported as moderately common to abundant except in San Diego County, where it was uncommon even in typical habitat (Sloan, 1964).

f. Pacific treefrog, Hyla regilla. Usually considered the most abundant anuran in coastal Southern California, Pacific treefrog is found near almost every pool of standing water in the

Figure 38. A mating pair of California tree frogs (Hyla cadavarina) on a stream gravel bank. Photograph courtesy of Alan Schoenherr.

San Gabriel Mountains (Schoenherr, 1976). Unlike the canyon treefrog, it also occurs in many other habitats. It prefers slow streams and inhabits a wide range of elevations (Sloan, 1964).

g. Red-legged frog, Rana aurora. This frog is an inhabitant of permanent pools, ponds, and marshes (Schoenherr, 1976). Formerly widely distributed, it has become scarce and local. Fully protected by the California Department of Fish and Game, it cannot be taken without a special permit. The bullfrog is a major predator on young red-legged frogs just emerging from the tadpole stage. It is still found in fair numbers locally along the Santa Margarita River (Zembal, 1984).

h. Mountain yellow-legged frog, Rana muscosa. This is one of two species of yellow-legged frogs in the mountains of Southern California, both of which have been collected in the same locality along the North Fork of the San Gabriel River in the San Gabriel Mountains. The mountain yellow-legged frog is found usually at higher elevations. Its preferred habitat is fast-flowing montane streams. While abundant in the San Gabriel Mountains in the 1950s (Schoenherr, 1976), its present status is not know.

i. Foothill yellow-legged frog, Rana boylei. This frog is found at lower elevations than the mountain species and prefers slower moving water and wide pools (Schoenherr, 1976). It has not been sighted since 1975 and may be extinct in Southern California.

j. Bullfrog, Rana catesbeiana. An introduced pond-dwelling species, the bullfrog has spread throughout coastal Southern California, except in the Santa Ynez River watershed. It has also been collected in streams (Schoenherr, 1976). Because it is a voracious predator, there is concern that is threatening the red-legged frog (S. Sweet, pers. comm.).

k. African clawed frog, Xenopis laevis. This is a recently introduced species that could spell disaster for some native amphibians, fish, and insects. Little is known about this frog except that it is spreading rapidly and has a voracious appetite. A study of its present distribution and impacts on native amphibians is urgently needed.

l. Western pond turtle, Clemmys marmorata. Found from British Columbia to Baja California, Mexico, mostly on the west side of the Cascade-Sierra crest to 2,400 m (Stebbins, 1966), this is the only turtle native to Southern California. Formerly abundant, it has declined in numbers as a result of habitat destruction and indiscriminate collecting. It is now protected by the Department of Fish and Game.

m. Western aquatic garter snake, Thamnophis couchi. This is a riparian snake that appears to prefer slow-moving parts of streams where pools form (Schoenherr, 1976). A live-bearer, it is found from sea level to the high mountains and feeds on fish and their eggs, frogs, toads, tadpoles, salamanders, earthworms, and leeches (Stebbins, 1966). Uncommon in Santa Barbara County (McKeown, 1974), it was not found in a recent survey of the coastal streams in Goleta (Onuf, 1983). It was found regularly along the Santa Margarita River in 1982 (Zembal, 1984b) where riparian habitat is still in near-pristine conditions. Like other riparian-dependent vertebrates, it may be in trouble and its status should be investigated.

In summary, only a few species of amphibians and reptiles in Southern California are riparian dependent. These include the California treefrog, red-legged frog, foothill yellow-legged frog, mountain yellow-legged frog, and western pond turtle. Many more use riparian habitat but are also found in other habitats. The obligate riparian species in general have suffered serious population declines, and one, the foothill yellow-legged frog, is probably extinct. The combined effects of habitat destruction (damming, channelizing, and cementing streambeds), introduction of exotic species, degradation of habitat by improper recreational use, and natural catastrophes such as major floods have all been devastating. The introduced bullfrog and African clawed frog are expanding their ranges at the expense of native anurans. To prevent further loss, coastal streams that still have natural segments should be preserved and protected, and control of introduced species should be top priority.

4.4 BIRDS

The complex subject of riparian birds can be addressed by analyzing types of use (breeding and nonbreeding); seasonality (wintering birds, migrants, summer visitors, residents); or relative abundance (common to rare species). Here the avifauna are divided into breeding and nonbreeding species, and other relevant topics are discussed in relation to this dichotomy.

In trying to draw the limits of riparian habitat for birds in Southern California, it is not possible to adhere to the strict definition given by the Oxford English Dictionary, i.e. "of, pertaining to, or living on the bank of a river." Ponds, lakes, marshes, and wet montane meadows are all intimately associated with streams in Southern California, and birds do not acknowledge boundaries. Riparian habitat thus has been divided into two major categories: streams and other types of freshwater communities. There is abundant overlap; many streamside birds also use marshes, wet meadows, and other freshwater habitats.

4.4.1 Breeding Birds

A checklist of the breeding birds, compiled from seven recent sources, is provided in Appendix A. Included are all species that have been documented as nesting in riparian habitat, whether or not they nest in other habitats as well. There are 140 species listed; 88 are riparian in the strict sense (nesting along valley and/or four montane streams); 23 nest along streams but also on ponds, lakes, marshes, and/or wet meadows; and 29 are not associated with streams but breed in other freshwater habitats. The degree of dependency on riparian habitat is noted for each species in column three; it encompasses obligate nesters, preferential nesters, birds that nest in many habitats including riparian, and occasional nesters. Miller (1951) rated the birds of California by nesting-habitat preference, recognizing 21 habitat types (including riparian woodland, freshwater marsh, etc.). For each species he listed all of the habitats where nesting had been documented, in order of preference. For some species there was only one listing; for others there were up to 12. Although the presentation here is different, there is no conflict between the data in the appended table and Miller's findings. Scientific nomenclature in the checklist follows the American Ornithologists Union Checklist (1983).

4.4.2 Distribution of Breeding Birds

Most breeding species are not limited by latitude and can be found throughout the Southern California coastal region. Exceptions are the wood duck (*Aix sponsa*), which breeds only on the Santa Ynez River and occasionally in the Santa Monica Mountains; the chestnut-backed chickadee (*Parus rufescens*) and yellow-billed magpie (*Pica nuttallii*), whose southern limit is the Tehachapi Mountains; and the common ground-dove (*Columbina passerina*), which is not found north of Orange County (Garrett and Dunn, 1981).

Altitudinal limitations are much more significant, as can be seen in Appendix A. Valley riparian habitat hosts 66 species of passerines, 29 of which are restricted to valley streams; the rest can nest from sea level to at least 2,800 m. Seven montane species are not found below 1,300 m (Grinnell and Miller, 1944).

The topography of the habitat is a major underlying factor in bird distribution, as it dictates the amount and type of vegetation, and thus nesting habitat. Broad, slow-moving valley rivers deposit large belts of sediment that support a rich and dense flora. The density and diversity of bird species along such watercourses (which are now relict in Southern California) are very great compared to that along mountain streams. Narrow gorges, steep grades, and fast flows characteristic of mountain streams prevent the deposition of sediment and thus limit the establishment of plants. Where the land flattens, whatever the altitude, wet meadows, cienegas, and even ponds develop, and the resulting vegetation provides nesting habitat.

4.4.3 The Breeding Season

The great wave of nesting takes place from May through July, when migrants returning from Central and South America join the resident birds, many of which have already been breeding for several months. The breeding cycles of resident birds in lowland riparian habitat are more attuned to the wet/dry cycle in Southern California than to such factors as photoperiod, temperature, or flowering, which trigger the migrants. Harrison (1979) gives beginning dates for nesting as early as December for Anna's hummingbird (Calypte anna) and California thrasher (Toxostoma redivivum), February for common bushtit (Psaltriparus minimus) and Hutton's vireo (Vireo huttoni), and March for Nuttall's woodpecker (Picoides nuttallii), hairy woodpecker (Picoides villosus), plain titmouse (Parus inornatus), and red-winged blackbird (Agelaius phoeniceus). The record for the longest nesting season probably goes to the resident subspecies of Allen's hummingbird, which has bred on Palos Verdes Peninsula in Los Angeles County every month except September and October (Wells and Baptista, 1979). Resident species that nest at high elevations, such as red-breasted sapsucker (Sphyrapicus ruber) and Cassin's finch (Carpodacus cassinii), follow a more restricted seasonal schedule similar to the migrants.

4.4.4 Needs of Breeding Birds

Riparian birds nest in living and dead trees, shrubs, reeds, grasses, rocky cliffs, soft banks, and rock ledges in streams and behind waterfalls. They also build floating nests on still waters.

Throughout the altitudinal range covered by coastal streams, willows (particularly willow thickets) are used for nesting. Valley species that prefer willows include the yellow-billed cuckoo (Coccyzus americanus), willow flycatcher (Empidonax traillii), Bell's vireo (Vireo bellii), and blue grosbeak (Guiraca caerulea). These species nest in the same type of habitat in the Sacramento Valley (Gaines, 1977). At higher altitudes, MacGillivray's warbler (Oporornis tolmiei) and black-headed grosbeak (Pheucticus melanocephalus) are closely associated with willows.

Oaks, which are often a component of the riparian tree community in the foothills, are preferred (and often essential) trees for the band-tailed pigeon (Columba fasciata), spotted owl (Strix occidentalis), saw-whet owl (Aegolius acadicus), acorn woodpecker (Melanerpes formicivorus), plain titmouse, Hutton's vireo, phainopepla (Phainopepla nitens), and dark-eyed junco (Junco hyemalis) (Verner, 1979).

Dead trees and snags of sycamores, willows, cottonwoods, oaks, and alders provide essential habitat for a large number of cavity nesters. All of the woodpeckers are in this group, plus such diverse species as the wood duck, American kestrel (Falco sparverius), several species of owl, ash-throated flycatcher (Myiarchus cinerascens), purple martin (Progne subis), house wren (Troglodytes aedon), and European starling (Sturnus vulgaris) (Grinnell and Miller, 1944).

Several species, such as the belted kingfisher (Ceryle alcyon), rough-winged swallow (Stelgidopteryx serripennis), and bank swallow (Riparia riparia), burrow into soft banks along streams to make nest cavities. Cliff swallows (Hirundo pyrrhonota) attach their mud nests to rock faces, and canyon wrens (Catherpes mexicanus) build twig nests on ledges or in crevices on rock faces (Grinnell and Miller, 1944; Gaines, 1974).

Two species with perhaps the most unusual adaptations to stream habitat are the black swift (Cypseloides niger) and the American dipper (Cinclus mexicanus). The swift's preferred nest site is on a ledge behind a waterfall; the dipper builds a nest under a rock ledge in a stream or under falls and it takes its food out of the stream as well.

Floating nests are built on ponds and lakes at low elevations by the pied-billed grebe (Podilymbus podiceps) and at high elevations by the eared grebe (Podilymbus nigricollis). Freshwater marshes in valley riparian habitat are favored nest sites for American bittern (Botaurus lentiginosus), black-necked stilt (Himantopus mexicanus), American avocet (Recurvirostra americana), shoveler (Anas clypeata), gadwall (Anas strepera), redhead (Aythya americana), and ruddy duck (Oxyura jamaicensis); both valley and montane marshes serve for sora (Porzana carolina) and Virginia rail (Rallus limicola), cinnamon teal (Anas cyanoptera), and mallard (Anas platyrhynchos) (Grinnell and Miller, 1944).

Colonially nesting birds that favor marshes are great blue heron (Ardea herodias), which nests in trees; snowy egret (Egretta thula) and cattle egret (Bubulcus ibis), which nest in tules and trees; and red-winged (Agelaius phoeniceus) and tri-colored blackbird (A. tricolor), which nest in cattails and tules.

Species with strong preferences for a particular type of nesting habitat are most vulnerable to the human presence. In some instances (e.g., black swift and American dipper), their specialized habitat is not particularly threatened. Others, particularly valley riparian species that nest preferentially in willow thickets, appear to be in great jeopardy (see 4.4.8).

A few species have shown their adaptability in exploiting new possibilities presented inadvertently by humans. Northern mockingbirds (Mimus polyglottos) are now seldom found nesting in riparian situations; they have taken to suburban gardens with great success. Cliff swallows (Hirundo pyrrhonota), barn swallows (H. rustica), and black phoebes (Sayornis nigricans) use bridges and other structures to support their nests. Barn owls (Tyto alba) do use barns, along with other dwellings. Hooded orioles (Icterus cucullaltus) have shown a partiality for palm trees (Garrett and Dunn, 1979). All of these species still nest in traditional sites in riparian habitat, but their adaptability makes them much less vulnerable than, for example, least Bell's vireo (see 4.4.8). None of them appears to be suffering a decline.

4.4.5 Food and Foraging

The following information is general knowledge from standard sources (Bailey, 1902; Bent, 1921-1958; Dorst, 1974).

Inhabitants of lakes and marshes get much of their food from the water and its substrate. Shorebirds and rails feed heavily on invertebrates in the water and in bottom mud; grebes, herons, and the belted kingfisher are primarily fisheaters; the various species of ducks are omnivorous and feed on roots, shoots, insects, grain, seeds, acorns, fish, newts, and frogs. Pigeons and quail are granivorous; hawks and owls are carnivorous and prey on lizards, snakes, birds, and rodents.

The passerines are primarily insectivorous and forage in every microhabitat. Flycatchers and swallows hawk insects in the air; chickadees, kinglets, wrens, vireos, and warblers glean insects mostly from foliage; the white-breasted nuthatch (Sitta carolinensis) and brown creeper (Certhia americana) work over the trunks and branches of trees; towhees, thrushes, and sparrows are often heard before being seen as they scratch on the ground in leaf litter. Woodpeckers drill into tree trunks and branches for insects, and one species, the acorn woodpecker, feeds on acorns as well. Fruits and berries are favorite foods of the phainopepla, cedar waxwing (Bombycilla cedrorum), American robin (Turdus migratorius), and northern mockingbird, all of which eat insects as well. Hummingbirds sip nectar, but a major component of their diet consists of insects.

The question of what, specifically, constitutes the diet of an insectivorous bird is more difficult to elucidate. Early in the century, biologists in the Bureau of Biological Survey spent a great deal of effort compiling data on what insectivorous birds eat. Much of the information was summed up by McAtee (1932) and showed that, in general, birds are great opportunists, not restricted to certain insects (there were, of course, exceptions) and able to take advantage of local outbreaks.

In Arizona, the foods of 13 species of riparian breeding birds were determined by stomach analysis. Eight species preyed heavily on cicadas; their nesting was timed closely with peak cicada numbers. Other foods included grasshoppers, bees and wasps, ants, spiders, and insect larvae (Rosenberg et al., 1982).

Studies of individual species can be found in the literature with some diligent searching, although there is little or nothing on California birds. Pinkowski (1978), studying eastern bluebirds (Sialia sialis) in Michigan, found that the foods they brought to their nestlings were lepidopteran larvae (36 percent), orthopterans (26 percent), spiders (11 percent), beetles (11 percent), earthworms (5 percent), and others (11 percent). Bierman and Sealy (1982), observing yellow warblers (Dendroica petechia) feeding their young in Manitoba, found them selectively bringing chironomids (midges), cuculids (mosquitoes), and geometrid (moth) larvae. The diet of adults, studied earlier (Busby and Sealy, 1979), was much more flexible. McNichol (1982) found that red-winged blackbirds switched from seeds and waste grain (their winter diet) to insects during the breeding season.

Studies of this type, done in Southern California's riparian habitat, would be helpful in broadening our understanding of the role of birds in riparian ecology.

4.4.6 Birds as Agents of Insect Control

McFarlane (1976) summarized the role of birds in controlling insects, covering research on forest, orchard, and crop insects and noting that the literature has long been dominated by studies of forest "pests," particularly those associated with conifers. The effectiveness of birds in controlling insect outbreaks was demonstrated in several studies, but others showed that birds had little impact. Warblers were reported to be outstanding consumers of insects, and one nomadic species, the evening grosbeak (Coccothraustes vespertinus) reportedly was attracted opportunistically to spruce budworm outbreaks. The consensus was that avian predators are not effective in controlling outbreaks, but are very important in control of endemic, or normal, population levels.

4.4.7 Changes in Status

There have been profound changes in populations of riparian birds during this century. Most species have declined in number; a few have increased. Valley species have suffered the most serious declines following the massive destruction of riverine habitat by dams and channelization that began early in the century.

Major sources of information about the status of riparian breeding species before World War II are Grinnell (1898, 1908), Ingles (1929), Willet (1933), Grinnell and Miller (1944), and Peguegnat (1951). Information on current status has been drawn from Webster et al. (1980) Garrett and Dunn (1981), Lehman (1982), Keeney and Loe (1984), and Unitt (1984). Three 1982-83 studies of special areas have been of particular value. The USFWS report (Zembal, 1984b) on the Santa Margarita River in San Diego County, based on breeding bird censuses in eight riparian plots along the river and two on the San Luis Rey River, gives an excellent account of breeding species. Another USFWS study (Zembal, 1984a) on the Santa Ana River upstream from Prado Dam in Riverside County was of lesser value only because it was less comprehensive. A good survey of the creeks that drain into Goleta Slough, undertaken for the Corps by Onuf (1983), gives detailed information on riparian birds in coastal Santa Barbara County. Unless otherwise indicated, the information in this and the following section was drawn from these sources.

Twenty-three species described as common or fairly common before 1940 are now much reduced in numbers: American bittern, least bittern (*Ixobrychus exilis*), great blue heron, snowy egret, great egret, whitefaced ibis (*Plegadis chihi*), Cooper's hawk (*Accipiter cooperii*), Virginia rail, sora, American avocet, barn owl, screech owl, hairy woodpecker, willow flycatcher, purple martin, bank swallow, western bluebird (*Sialia mexicana*), loggerhead shrike (*Lanius ludovicianus*), yellow warbler, Wilson's warbler (*Wilsonia pusilla*), yellow-breasted chat (*Icteria virens*), blue grosbeak, and Lazuli bunting (*Passerina amoena*). Six species that were already showing population reductions by the 1930s have continued to decline: northern harrier (*Circus cyaneus*), red-shouldered hawk (*Buteo lineatus*), yellow-billed cuckoo, belted kingfisher, least Bell's vireo, and yellow-headed blackbird (*Xanthocephalus xanthocephalus*). The black rail (*Laterallus jamaicensis*), now a rare breeding bird in Southern California, is so secretive that its status in the past is uncertain; it may never have been more abundant (Wilbur, 1974). A few species apparently have increased in numbers; they are birds that adapt well to urbanization: American kestrel, American crow (*Corvus brachyrhynchos*), northern mockingbird, and house finch (*Carpodacus mexicanus*).

4.4.8 Species of Special Concern

Riparian-associated species considered endangered, rare, sensitive, or of special concern by the California Department of Fish and Game (1980), the USFWS (1982, 1983), or the National Audubon Society (NAS) (Tate and Tate 1982) are shown in Table 9. Some of the species listed by NAS, such as Bewick's wren (*Thryomanes*

Table 9. Endangered, rare, and sensitive bird species in Southern California.

	CDFG			USFWS		NAS	
Species	E	R	S	E	S	BL	SC
American bittern						x	
Least bittern			x	x			
White-faced ibis			x	x			
Northern harrier			x			x	
Cooper's hawk			x				x
Red-shouldered hawk						x	
Black rail						x	
Yellow-billed cuckoo		x					
Long-eared owl			x				
Hairy woodpecker						x	
Willow flycatcher			x	x		x	
Purple martin			x				x
Western bluebird					x		
Loggerhead shrike					x		x
Least Bell's vireo	x			x			
Yellow warbler					x	x	
Yellow-breasted chat			x				

CDFG = California Department of Fish and Game, 1980; Remsen, 1979
USFWS = U.S. Fish and Wildlife Service, 1980, 1982
NAS = National Audubon Society, Tate and Tate, 1982
E = Endangered Species, R = Rare, S = Sensitive,
BL = Blue List, SC = Special Concern

bewickii), are considered scarce in various parts of their ranges, although not in Southern California; they have not been included here. Eight species appear on more than one list, and the willow flycatcher is listed by all three compilers.

There are others not yet listed but acknowledged as becoming scarce in Southern California: blue-grey gnatcatcher (Polioptila caerulea) and warbling vireo (Vireo gilvus) are almost extirpated as breeders in San Diego County (Unitt, 1984); blue grosbeak, Lazuli bunting, and Wilson's warbler are now uncommon breeders in the lowlands; belted kingfisher and yellow-headed blackbird are now extremely rare breeders in coastal Southern California, and bank swallow has virtually disappeared (Garrett and Dunn, 1981).

The following birds appear to be of most concern in Southern California; they are listed in order of the American Ornithologists Union Checklist (1983), not necessarily in order of priority of concern. Some species listed in Table 9 are not included because they are doing well in Southern California or have always been scarce. Unless otherwise stated, documentation is from the same sources listed in 4.4.7.

a. Cooper's hawk, Accipiter cooperii. Cooper's hawk nests preferentially in riparian habitat from sea level to about 2,600 m, most often in live oaks and sycamores, but more often in the lowlands. The major reason for its decline is habitat loss.

b. Yellow-billed cuckoo, Coccyzus americanus. Nesting only in valley riparian habitat, the yellow-billed cuckoo prefers old-growth willows and cottonwoods with a dense understory of blackberry and grape. It is almost extirpated as a breeding bird in coastal Southern California, the only recent record being on the Santa Ana River in 1983. Loss of habitat is considered the major reason for decline, but other factors such as pesticides may also be involved (Gaines, 1977).

c. Long-eared owl, Asio otus. The long-eared owl breeds only in valley riparian habitat, preferring tall willows, cottonwoods, and live oaks. Already declining in the 1930s and now extremely rare, it has been found recently in small numbers along the Santa Margarita River, Santa Ana River, and on Starr Ranch Audubon Sanctuary. In San Diego County it has been documented recently only in the desert. Loss of habitat is the major reason for its decline.

d. Belted kingfisher, Ceryle alcyon. The belted kingfisher nests in burrows excavated in earthern banks along streams or lakes. By 1940, already reduced in numbers, it was targeted by fishermen as "vermin" and shot regularly (Grinnel and Miller, 1944). The only recent records for San Diego County show two nesting pairs on the Santa Margarita River in 1982-83. This bird is not on any list. Its present rarity is presumably due to lack of suitable nesting habitat. A survey of the breeding population should be done to ascertain status.

e. Hairy woodpecker, Picoides villosus. This woodpecker nests in montane forests where there are dead trees or limbs for nest holes; in foothill canyons in the lowlands it nests in riparian trees. Considered common and sometimes abundant formerly, it is still fairly common in the mountains, but much reduced at lower elevations. Destruction of lowland riparian habitat is the prime cause of decline (Yeager, 1955).

f. Willow flycatcher, Empidonax traillii (Figure 39). Nesting only in willow thickets along valley streams and mountain canyons, the willow flycatcher was formerly common where conditions were suitable; it is now extremely rare in Southern California. The presence of a few singing males on the Santa Margarita River, Sun Luis Rey River, and several other locales in San Diego County in 1982 and one on the Santa Ana River in 1983 indicate that there are still a few pairs in the lowlands. There is no information for the mountains. A combination of habitat loss and parasitism by the

Figure 39. Willow flycatcher (Empidonax traillii), nesting only in willow thickets, is now extremely rare. Drawing by Narca Moore-Craig.

brown-headed cowbird are major causes of its present plight.

g. Purple martin, Progne subis. The purple martin nests in cavities in large trees, often old woodpecker holes, in riparian and other habitats where such nest sites are available. Deemed fairly common in the 1930s, it is now rare and localized. Elsewhere in the country it has readily adapted to nest boxes, but not in Southern California. A few still breed in the Santa Ynez Valley, mostly around Nojoqui Falls Park. The European starling, an aggressive and social species with the same nesting preferences, is implicated in its decline.

h. Bank swallow, Riparia riparia. A colonially nesting species that digs into sandy banks along sea bluffs and the lower reaches of streams to make nest holes, the bank swallow was described by Grinnell and Miller (1944) as the least numerous of the swallows in California. Its specialized breeding requirements have always been a limiting factor. It is not on any list.

i. Blue-gray gnatcatcher, Polioptila caerulea. This gnatcatcher breeds in chaparral, oaks, and riparian woodlands, mostly on the coastal slopes in Southern California. Once common, it is now drastically reduced as a breeding bird. A few pairs probably nested along the Santa Margarita River in 1982, but there are no other recent records in coastal Southern California. Cowbird parasitism is presumed to be the major problem. Its status should be ascertained.

j. Loggerhead shrike, Lanius ludovicianus. The loggerhead shrike nests in shrubs and trees in open areas, farmlands, open oak woodlands, arroyos, and river bottoms. It once was common to abundant in Southern California, and is still fairly common in much of the State. This species is probably not in serious trouble in Southern California, although it is of concern in other parts of the country.

k. Least Bell's vireo, Vireo bellii pusillus. This small vireo nests in willows in valley riparian woodland and foothill canyons where there is a dense understory of herbaceous and shrubby plants. It was common and even locally abundant until about 1930, but was already in noticeable decline by 1940, coincident with the huge increase in brown-headed cowbirds (Verner and Ritter, 1983). Least Bell's vireo is now a rare breeder with much of the population concentrated along the Santa Ynez River (Gray and Greaves, 1984) and on the Santa Ana, Santa Margarita, San Luis Rey, and San Diego Rivers (Goldwasser, et al. 1980). Fewer than 100 breeding pairs could be located in 1977-78 (Goldwasser, 1980). In addition to severe parasitism by cowbirds, there has been massive destruction of valley riparian habitat; these two factors in combination have reduced this vireo to endangered status (Figure 40). In May 1986 it was added to the Federal endangered species list (51FR 16474).

l. Warbling vireo, Vireo gilvus. This vireo nests in deciduous trees in riparian habitat; it was said by Grinnell and Miller (1944) to be dependent on the trees rather than on the proximity of water. It was common in valley and montane riparian habitat up to 3,400 m, but the effects of cowbird parasitism were already evident in the early 1940s. Now it is uncommon in valley riparian habitat and nearly exterminated in San Diego County, with only a few pairs still breeding on the Santa Margarita and San Luis Rey Rivers. It still breeds in coastal Santa Barbara County in limited numbers (13 pairs were found on San Jose Creek in 1983). It may be faring better in the mountains, but its status needs investigation. It is not yet on any list; its decline is probably due chiefly to parasitism by cowbirds and loss of habitat.

Figure 40. Least Bell's vireo (Vireo bellii pusillus), recently listed as an endangered species, suffers from habitat loss and cowbird nest parasitism. It is shown here feeding a brown-headed cowbird. Drawing by Cameron Barrows.

m. Yellow warbler, Dendroica petechia. This warbler nests in deciduous trees and shrubs in riparian habitat in the lowland valleys and up to about 2,800 m. It was common and even locally abundant in the 1940s; it has declined considerably in the lowlands, although pockets of breeding birds are still present in Santa Barbara County, along the Santa Ana River in Riverside County, and along the Santa Margarita and San Luis Rey Rivers and probably several others in San Diego County. Its status in the mountains is not known. Cowbird parasitism and loss of habitat are major factors in its decline.

n. Wilson's warbler, Wilsonia pusilla. This black-capped warbler nests close to the ground in willow thickets and dense shrubs along streams, favoring the humid coastal belt and high, wet montane meadows. It is now an uncommon breeder in both habitats. A few may still nest along the Santa Ynez River. It is not on any list. Cowbird parasitism and loss of habitat are the major problems.

o. Yellow-breasted chat, Icteria virens. Nests are placed in low, dense riparian growth, particularly willow thickets and tangles of blackberries and grapes in lowland valleys and foothill canyons. Formerly fairly common, it is now an uncommon and local breeder in small numbers along the Santa Ynez and Santa Ana Rivers. Loss of riparian habitat is the major reason for its decline; cowbird parasitism may be involved and should be investigated.

p. Blue grosbeak, Guiraca caerulea. The blue grosbeak nests in low, thick riparian vegetation in the valleys and foothills to about 1,600 m. It was once fairly common where appropriate habitat occurred but is now reduced in numbers. The greatest concentration reported recently was about 25 pairs on the Santa Ana River. It is rare and localized in coastal Santa Barbara and San Diego Counties. It is not on any list. Causes of its decline include loss of habitat and perhaps cowbird parasitism. Its status needs investigation.

q. Lazuli bunting, Passerina amoena. This songster breeds along watercourses, usually in adjacent vegetation on drier ground, from sea level to at least 3,000 m. It was common and is still fairly common locally in the lowlands in Santa Barbara County and along the Santa Ana and Santa Margarita Rivers, but its status is not well known. It is probably still doing well in the mountains. It is not on any list.

Several species that breed preferentially in freshwater marshes have declined sharply in numbers since the 1940s. The Virginia rail, sora, American bittern, and least bittern are rarely found breeding now. These birds, like the black rail, are secretive and hard to count, but used to be common enough to be reported regularly. The yellow-headed blackbird, never common in Southern California, was already reduced in numbers in the 1940s. There has been no recent documentation of nesting, and it may be extirpated as a breeding bird in coastal Southern California.

4.4.9 Expanding Species

Four species that have expanded their ranges into Southern California (as opposed to introduced species) are of concern because of their impact or potential impact on native birds:

a. Cattle egret, Bubulcus ibis. First recorded in California in 1964 at Imperial Beach, San Diego County, this adaptable heron has spread widely and is now common in coastal Southern California, including Santa Barbara County. The first documented nesting was at the Salton Sea in 1970; it is now the most abundant heron there and has largely displaced the snowy egret. It has nested recently in brackish lagoons and freshwater marshes in coastal San Diego and Riverside Counties and is still expanding its range northward.

b. European starling, Sturnus vulgaris. Now an abundant bird in Southern California, the European starling first appeared in the late 1940s. A cavity-nester and an aggressive, social species, it often breeds in valley riparian woodland, usurping the nest holes of other birds. Although it has often been stated that the starling is causing the decline of other species such as the common flicker and purple martin, there are no data to confirm this assumption. Troeschler (1976) studied the impact of starlings on a community of acorn woodpeckers and found that, although the starlings usurped their holes, the woodpeckers excavated new ones and their population remained stable over the 6-year study period. Troeschler also reviewed the literature and could find no documentation of the decline of a species attributable to starlings.

c. Brown-headed cowbird, Molothrus ater. The cowbird was not listed as occurring in Los Angeles County in 1898 (Grinnell, 1898) but was well established by 1933 (Willet, 1933). Its rapid range expansion and exploding population in California in this century are associated with the spread of agriculture and cattle grazing. It is a brood parasite that lays its eggs in the nests of other birds, particularly small passerines. The host species incubates the eggs and then feeds the young at the expense of its own progeny. It is strongly implicated in the decline of the least Bell's vireo (Goldwasser, 1980); indeed, the first published account of cowbird breeding in San Diego County was a case of parasitism of the Bell's vireo (Unitt, 1984). The cowbird also parasitizes the willow flycatcher, warbling vireo, blue-gray gnatcatcher, yellow warbler, and Wilson's warbler in lowland riparian habitat. As of 1977, cowbird eggs had been found in the nests of 216 species, including some unlikely hosts that do not feed their young, such as the spotted sandpiper and killdeer (Friedman et al., 1977). Recent accounts of cowbird activity in the Sierra Nevada document its ubiquity in the high mountains, where it parasitizes at least 22 species of small passerines (Rothstein, 1980) and is implicated in the decline of the warbling vireo (Verner and Ritter, 1983). Cowbird control has been advocated by several investigators (Goldwasser, 1980; Salata, 1983), particularly where remaining small populations of the least Bell's vireo are threatened.

d. Great-tailed grackle, Quiscalus mexicanus. A newcomer to coastal Southern California, the great-tailed grackle was first found nesting in riparian habitat in sizable numbers along the Santa Ana River in 1983. The grackle population has increased in size and expanded its range in interior southeastern California since the first record of its appearance in 1964. Associated with farming and ranching, it is likely to become a common resident, as have the cowbird and starling. Its impact on native birds remains to be seen.

4.5 NONBREEDING BIRDS

Great waves of migrants, mostly passerines, move through Southern California's riparian areas in spring and fall. They are transients, but the habitat is nevertheless critical for their needs; food and rest stops are an essential feature of successful migration. Year-round nonbreeding users compose a small group, foraging in riparian habitat but breeding in grassland, pine forest, or other nearby habitat. This group includes such species as the introduced ring-necked pheasant (Phasianus colchicus), mountain chickadee (Parus gambeli), and pine siskin (Carduelis pinus). A few species are present only in summer as visitors, such as the California least tern (Sterna antillarum) and lesser nighthawk (Chordeiles acutipennis), which feed in or over lakes and marshes while breeding elsewhere in the region. It may seem odd to list the California least tern as a freshwater forager, but there is ample documentation for this statement (Lehman, 1982; Atwood and Minsky, 1983).

Wintering birds are major users of riparian habitat (see 4.5.1); these are migratory birds that stay through the winter in Southern California, as opposed to migrants that continue south to winter in the tropics. The winter population includes also those breeding birds that are residents.

4.5.1 Winter Bird Use

Avian use of valley riparian habitat in the upper Santa Ana River wash was well documented earlier in the century by Ingles (1929). He found 43 species in a 6-month period between October and April. For 33 of them, riparian was the preferred habitat among the four plant communities investigated. All but three were residents; the three wintering species were ruby-crowned kinglet (Regulus calendula), yellow-rumped warbler (Dendrocia coronata), and white-crowned sparrow (Zonotrichia leucophrys). The most abundant species were lesser goldfinch (Carduelis psaltria) and bushtit (Psaltriparus minimus).

Since 1975 there have been many winter bird population studies in valley and foothill riparian habitats in coastal Southern California. Areas covered include creeks, lakes, marshes, and rivers in Santa Barbara, Los Angeles, Orange, Riverside, and San Diego Counties.

Appendix B lists species from 25 winter bird counts reported in American Birds between 1975 and 1984. Eight of these winter bird counts were done on the Santa Margarita River in San Diego County in 1982 (American Birds, 38(1):46-51). They give the most comprehensive data on current winter bird use because they were all done along one 12-mi stretch of the river. Ninety-four species were detected, including all of those seen by Ingles in 1929. In order of abundance the 15 most common were: song sparrow (Melospiza melodia), yellow-rumped warbler, bushtit, lesser goldfinch, common yellowthroat (Geothlypis trichas), ruby-crowned Kinglet, Bewick's wren, rufous-sided towhee (Pipilo erythrophthalmus), American goldfinch (Carduelis tristus), house finch (Carpodacus mexicanus), wrentit (Chamaea fasciata), red-winged blackbird, plain titmouse (Parus inornatus), white-crowned sparrow, and Hutton's vireo. All but three (yellow-rumped warbler, ruby-crowned kinglet, white-crowned sparrow) were residents. Song sparrow and yellow-rumped warbler were the most abundant; each was more than twice as numerous as the next most abundant bird on the list. Nine species were among the top fifteen in both the Ingles (1929) study and the 1984 Santa Margarita study: bushtit, Bewick's wren, yellow-rumped warbler, rufous-sided towhee, brown towhee (Pipilo fuscus), song sparrow, white-crowned sparrow, house finch, and lesser goldfinch.

Montane riparian habitat has been neglected in winter bird censuses; there are no published studies of current winter bird use.

4.5.2 Taxonomic Aspects of the Riparian Bird Community

The importance of riparian habitat for birds is discussed in Chapter 5; however, it is interesting to note that birds breeding in riparian habitat in coastal Southern California belong to fourteen different orders. Table 10 lists them phylogenetically (AOU, 1983) and shows species preferences within the riparian habitat (the tree/shrub community along the streams or the more open lake/marsh/wet meadow habitat). Three generalizations can be made from examination of the list.

First, passerines (Passeriformes) are the dominant order, comprising 54 percent of the avian species that breed in Southern California's coastal riparian habitat.

Second, birds that nest in marshes, lakes, and wet meadows are predominantly estuarine birds (grebes, herons, rails, waterfowl, shorebirds) that have moved inland to use freshwater habitats similar to coastal lagoons and marshes. Many are large and not particularly aerial; they tend to nest on the ground or on water and find their food in the water or in soil associated with water.

Table 10. Avian species breeding in riparian habitat in Southern California (listed by order).

Order	Habitat[2]			
	Stream	Marsh	Both	Total
Podicipediformes (grebes)		3	3	
Ciconiiformes (herons)	8	1	9	
Anseriformes (swans, geese, ducks)	1	7	8	
Falconiformes (hawks, falcons)	5		1	6
Galliformes (quail, grouse)	2		2	
Gruiformes (cranes, rails)	5	5		
Charadriiformes (shorebirds)	4	1	5	
Columbiformes (pigeons, doves)	4		4	
Cuculiformes (cuckoos)	1		1	
Strigiformes (owls)	8		8	
Apodiformes (swifts, hummingbirds)	3		3	6
Coraciiformes (kingfishers)	1		1	
Piciformes (woodpeckers)	6		6	
Passeriformes (perching birds)	59	3	14	76
TOTALS	90	30	20	140

[a]Stream = streamside habitat; Marsh = marshes, lakes, wet meadows.

Third, passerines are the predominant streamside birds, both in number of species and in number of individuals. They are generally smaller, nest in trees and shrubs, and are predominantly insectivorous. Many are migratory.

The close association of passerines with riparian habitat, and particularly the affinity shown by tropical species that migrate north to breed (e.g., flycatchers, swallows, vireos, warblers), is so marked that it deserves more attention. This group is now under severe pressure because of destruction of the tropical forests where they winter; they are thus pressed for habitat on both breeding and wintering grounds.

In summary, the riparian areas of coastal Southern California provide breeding habitat for 140 species of birds. The vast majority are residents, joined in spring by migrants from south of the U.S. border. Nest sites include trees, dead snags, shrubs, reeds, grasses, cliff banks, and water (floating nests). Food for these birds ranges from minute invertebrates to small mammals. Only a few species are granivorous; the largest group, the passerines, consists mainly of insectivores.

Loss of riparian habitat in this century has resulted in the decline of many species, particularly those that have inflexible breeding requirements. Several are close to extirpation from coastal Southern California, including the yellow-billed cuckoo, least Bell's vireo, and willow flycatcher. Seventeen species are listed by various agencies as endangered, threatened, or of special concern. Conversely, a few of the more adaptable species have increased in numbers (e.g., northern mockingbird, house finch).

In addition to providing nesting habitat, riparian areas serve as major stopovers for migratory birds and as wintering areas for many species that go to northern latitudes to breed.

The value of riparian habitat for birds has been well documented; it supports more species of breeding birds than any other type of plant community in California. As nesting habitat for passerines it has special importance; 54 percent of the avian breeding species in riparian areas are members of this order.

4.6 MAMMALS

Forty-four species of mammals can be found in association with Southern California's riparian habitat. Appendix C lists them and indicates the degree of dependency for each. Numerical values are intended only as indicators; some are undoubtedly open to challenge. Four species are not native to Southern California; one, the Virginia opossum (<u>Didelphis virginiana</u>), was introduced from the eastern United States, but the beaver (<u>Castor canadensis</u>), red fox (<u>Vulpes fulva</u>), and black bear (<u>Ursa americanus</u>) were resident in the Sierra Nevada and introduced into Southern California from there.

Several species are limited in their latitudinal range. The northern flying squirrel (<u>Glaucomys sabrinus</u>) does not occur south of the San Jacinto Mountains and is localized in the San Gabriel, San Bernardino, and San Jacinto mountains (Keeney and Loe, 1984). The porcupine (<u>Erethizon dorsatum</u>) has its southern limit in the San Bernardino Mountains (Keeney and Loe, 1984). The long-tongued bat (<u>Choeronycteris mexicana</u>) is a Mexican species that barely extends north into lower San Diego County (Bond, 1977).

Several species have altitudinal range limits. The Virginia opossum, ringtail mouse (<u>Bassariscus astutus</u>), and pinyon mouse (<u>Peromyscus truei</u>) are not reported from the high mountains; the northern flying squirrel is found only at high elevations.

Streams serve as corridors for the spread of some mammalian species. Grinnell (1933) noted that the opossum followed stream courses up into the foothills. The western grey squirrel (<u>Sciurus griseus</u>) is restricted to oak woodland, and its geographic distribution in Southern California has been influenced by the presence or absence of riparian "bridges" between mountains (Pequegnat, 1951). The red fox has spread by moving along rivers and has become well established in several salt marshes--e.g., in Mugu Lagoon and at Seal Beach National Wildlife Refuge--within the past decade by using riparian corridors.

4.6.1 Riparian-Associated Mammals

The following annotated list includes mammals that are most closely associated with riparian habitat (Category 1, column 4, Appendix C) or use riparian as well as other habitats (Category 2), but not casual users (Category 3). The nomenclature follows Hall (1981).

a. Virginia opossum, Didelphus virginiana. The Virginia opossum is not native to the Pacific Coast, but is found throughout California except in the coldest and driest regions (Ingles, 1965). Already present in the San Gabriel River bottom in 1906 (Grinnell, 1933), it occurs commonly around human habitation, in woodlands, and along streams (Burt and Grossenheider, 1964) and is still common in riparian habitat along the Santa Margarita River (Zembal, 1984b). Omnivorous, it is known to eat fruit, eggs, young birds, and small mammals (Ingles, 1965).

b. Ornate shrew, Sorex ornatus. The ornate shrew is resident along streams in valleys, foothills, and high mountains throughout coastal Southern California. Closely associated with riparian habitat, it is very common along the Santa Margarita River (Zembal, 1984b). Its diet is not well known but includes the larvae, pupae, and adults of many insects (Ingles, 1965). Its role in riparian ecology merits study.

c. Broad-footed mole, Scapanus latimanus. Widely distributed in California at all elevations, this mole is most common in mountains where it burrows in soft soil in stream valleys and meadows. Its habitat may be dictated more by the presence of soft soil than by water (Bond, 1977).

d. Botta's pocket gopher, Thomomys bottae. A ground-burrowing mammal widely distributed in California (except in the highest mountains), Botta's pocket gopher also burrows in soft soil in valleys and meadows. Found up to 3,600 m in wet meadows of the San Bernardino Mountains (Grinnel, 1908), it is also quite common in the riparian/upland interface and locally in riparian habitat along the Santa Margarita River (Zembal, 1984b). It is eaten by owls, hawks, coyotes, foxes, badgers, and snakes (Ingels, 1965). A vegetarian, feeding on grasses and plants in natural situations (Ingles 1965), it is considered beneficial in mountains, where it "ploughs" the soils, but a pest in orchards, grain fields, and farms, where it gnaws roots and stems.

e. Bats. As an order, bats are closely associated with freshwater habitat. Most species are aerial insectivores and feed on concentrations of insects over or close to streams and lakes. In Southern California only one species does not feed on insects: the long-tongued bat, a tropical nectar feeder that occasionally strays north into San Diego County (Bond, 1977). The thirteen species on the checklist (Appendix C) are represented by multiple specimens in museum collections in California. There are no major roosts in coastal Southern California, as there are no large caves or mines. The most common bat in Southern California riparian habitat is the western pipistrelle (Pipistrellus hesperus), which frequents both lowlands and mountains. Other common species are Yuma myotis (Myotis yumanensis), California myotis (Myotis californicus), big brown bat (Eptesicus fuscus), and Mexican free-tailed bat (Tadarida brasiliensis). The hoary bat (Lasiurus cinereus) used to be much more common; it was often collected in summer in the mouths of canyons in Beverly Hills, Glendale, and Pasadena (D. McFarlane, Natural History Museum, Los Angeles County; pers. comm.). Loss of habitat has reduced the local distribution of this and several other species now found mostly at higher elevations.

Bats in Southern California roost in trees (long-eared myotis, red bat, hoary bat), in buildings (California myotis, big brown bat), and on cliff faces (western mastiff bat) (Barbour and Davis, 1969). They are all small mammals that would not be expected to fly more than a few miles to forage, so their roosting sites are close to where they are seen and collected (D. MacFarlane, pers. comm.).

f. Beaver, Castor canadensis. Beaver is not native to Southern California, but was widely introduced and is now resident in both valley and mountain streams. In San Diego County it is found on the Sweetwater River, in the Cuyamaca Mountains, and along the San Luis Rey River in the lowlands (Bond, 1977). It is also abundant along the Santa Margarita River (Zembal, 1984b), in streams in the San Bernardino Mountains, and along San Juan Creek (Figure 41). The beaver is vegetarian, feeding on bark and twigs of alder, willow, maple, and other trees. Its only real predator is man.

g. Western harvest mouse, Reithrodontomys megalotis. This mouse occurs in many habitats but prefers dense vegetation close to water. It has been trapped recently along coastal creeks in Santa Barbara County and on the Santa Margarita River (Onuf 1983; Zembal, 1984b). It eats seeds, fruit, and insects.

h. California mouse, Peromyscus californicus. Resident in foothill woodlands, coastal sage scrub, and chaparral in coastal Southern California. A seasonal shift in habitat use was noted on the Santa Margarita River, where it was most abundant in riparian habitat in spring and summer and in coastal sage scrub in winter (Zembal, 1984b). It has been found in close association with Neotoma in the Santa Ana Mountains (Pequegnat, 1951). Reported to feed on insect larvae as well as seeds

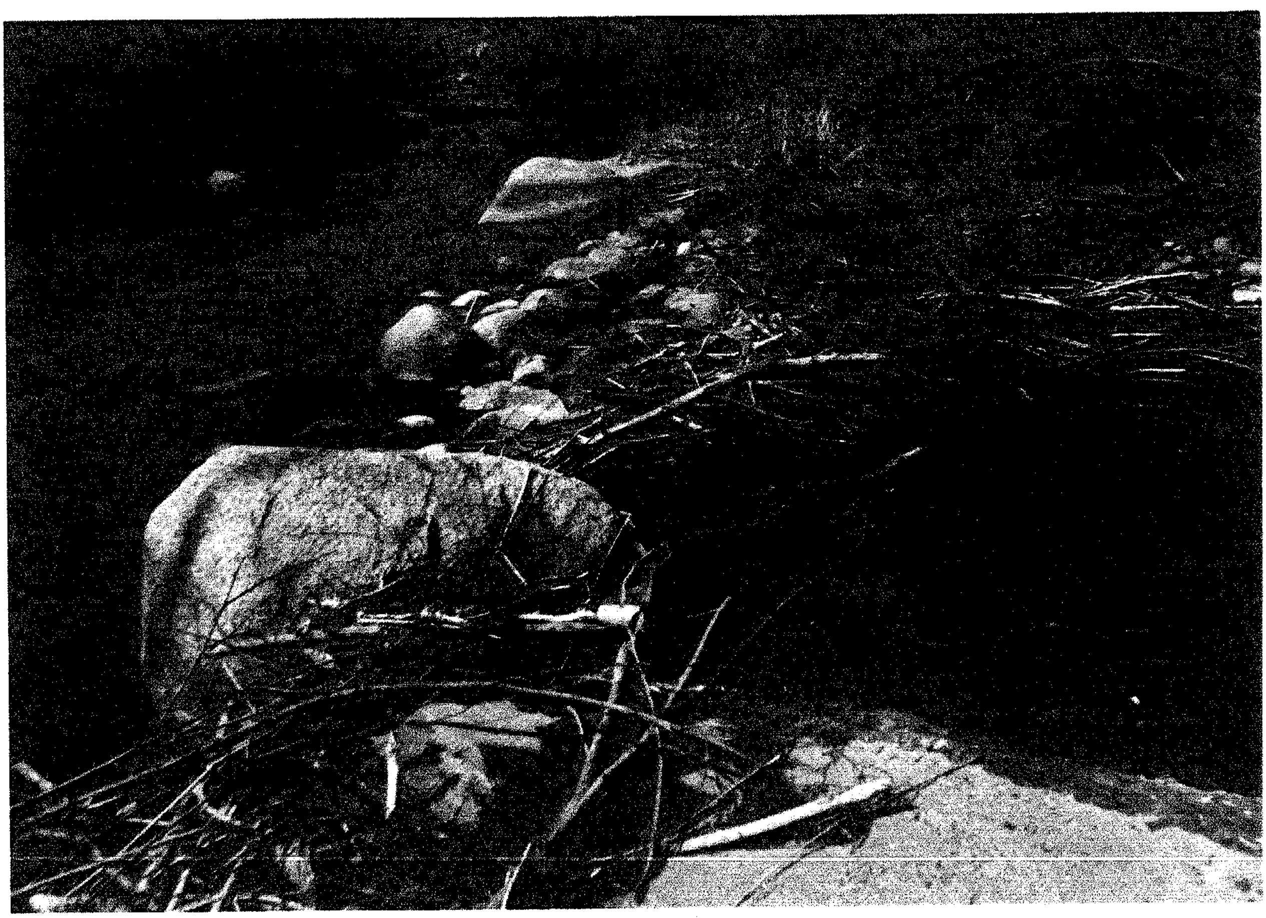


Figure 41. A beaver dam on the Santa Margarita River.

(Ingles, 1965), it is itself prey for many birds and mammals.

i. Deer mouse, Peromyscus maniculatus. Widely distributed across the United States, the deer mouse is found in all habitats. Although not particularly identified with riparian habitat, it was found there abundantly in winter along the Santa Margarita River (Zembal, 1984b). It feeds on seeds, nuts, acorns, insects (Burt and Grossenheider, 1964) and is prey for many birds and mammals.

j. Brush mouse, Peromyscus boylii. Although supposedly a resident of arid regions, this mouse has been found regularly in riparian habitat in the San Bernardino Mountains (Grinnell, 1908), the San Gabriel Mountains (Vaughn, 1954), the Santa Ana Mountains (Pequegnat, 1951), and along the Santa Margarita River and its drainage in the coastal lowlands (Zembal, 1984b). It was the most common rodent trapped in the streamside/willow woodland community in the Santa Ana Mountains by Pequegnat (1951). It feeds on pine nuts, acorns, seeds, and berries (Burt and Grossenheider, 1964) and is prey for many birds and mammals.

k. Dusky-footed woodrat, Neotoma fuscipes. Widespread in California from sea level to high in the foothills, the dusky-footed woodrat prefers heavy chaparral, streamside thickets, and deciduous and mixed woodlands (Burt and Grossenheider, 1964). It is widely reported in the San Bernardino Mountains (Grinnell, 1908), the San Gabriel Mountains (Vaughn, 1954), and the Santa Ana Mountains (Pequegnat, 1951), as well as along coastal streams in Santa Barbara County (Onuf, 1983) and San Diego County (Zembal, 1984b). It is vegetarian and itself food for owls, foxes, coyotes, and large snakes (Ingles, 1965).

l. California vole, Microtus californicus. The California vole prefers marshy ground and meadows along streams from lowlands to high mountains the length of the state (Burt and Grossenheider, 1964). Common in the local mountains (Grinnell, 1908; Vaughn, 1954; Pequegnat, 1951) and along coastal creeks in San Diego County (Zembal, 1984b), it feeds on grasses, sedges, and other green vegetation (Burt and Grossenheider, 1964).

m. Raccoon, Procyon lotor. Raccoon is widely distributed in California along watercourses and lakes in valleys and foothills, but not at high elevations (Ingles, 1965). Omnivorous, it frequently washes its food before eating it. Its preferred habitat is close to streams, lakes, and marshes (Grinnell, 1933). It is probably an important predator on bird eggs, and this merits study.

n. Ringtail, Bassariscus astutus. A secretive, nocturnal mammal, ringtail until recently was believed to prefer brush and rocky slopes (Ingles, 1965). Two studies have now documented a preference for riparian habitat; one in Texas (Toweill and Teer, 1980), another in the Central Valley of California (Belloumini, 1983). Found in lowlands and foothills, but not often at high elevations, it feeds on small rodents, occasional birds, and fruit (Ingles, 1965).

o. Long-tailed weasel, Mustela frenata. Long-tailed weasel has been found in all habitats that are close to water and at all elevations (Ingles, 1965). Carnivorous, feeding on small rodents and occasional rabbits, birds, and eggs, it is active in daylight but also hunts at night. An agile climber, it may be an important predator on bird eggs.

p. Spotted skunk, Spilogale putorius. Spotted skunk is found in brush or wooded areas near streams at all elevations (Ingles, 1965). In Southern California it is most often noted at low elevations (Grinnel, 1908; Pequegnat, 1951; Bond, 1977) and is frequently near human habitation. Distributed through most of the western United States, it is a nocturnal hunter that preys on insects, rodents, birds, and eggs. It can carry rabies.

q. Striped skunk, Mephitis mephitis. Striped skunk is found in logged-over areas, weedy fields, and streamside thickets where food is abundant (Ingles, 1965) in lowlands and mountains up to at least 2,600 m (Grinnell, 1908). It is distributed throughout the United States. Primarily a nocturnal hunter, it also forages by day, eating insects, rodents, eggs, carrion, and almost anything available. It is taken for its fur. It sometimes carries rabies (Burt and Grossenheider, 1964).

4.6.2 Status of Riparian Mammals

The role of mammals in riparian ecology and the value of riparian habitat for mammals are discussed in Chapter 5. There are no riparian-dependent mammals on either State or Federal lists of endangered, rare, or sensitive species. There are some whose status is not well known and should be investigated. The ringtail is a secretive animal about which little is known. Belloumini (1983) found densities of 10.5 to 20.5 ringtails per hectare in riparian habitat in California's Central Valley. A comparative study in Southern California would be of interest. Bats are an even more difficult object of study; the range, population size, habitat preferences, and needs of the 13 species associated with riparian habitat in Southern California are poorly known. Most scientific work on bats has been taxonomic, and an atlas of the bats of Southern California is in preparation at the Los Angeles County Museum. Field studies would also be useful.

In summary, 44 species of mammals are associated with riparian habitat in coastal Southern California; they range in size from the tiny California vole to the black bear. Although the large mammals (deer, bighorn sheep, bear) are not associated primarily with riparian habitat, they use it daily for water and forage. Mammals are both predators and prey in the food chain; small rodents are prey for both birds and larger carnivorous mammals. Bats are the least-known order of mammals associated with riparian habitat, although there are 13 riparian-associated species.

4.7 SUMMARY

California's insect fauna is huge, encompassing an estimated 27,000 to 28,000 species. Riparian insects fill a variety of ecological niches and play an important role in the riparian community as both predators and prey.

Fish populations in Southern California are limited in diversity and size and are disappearing rapidly because of habitat destruction, particularly from dams and channelization projects.

Amphibians are present around undisturbed mountain streams and lowland rivers but are scarce or eliminated where riparian habitat is disturbed or destroyed or where recreational use is heavy.

Of 140 species of breeding birds listed for Southern California, 88 are strictly riparian and 23 are users of riparian habitat. Eighty-two species of nonbreeding birds are listed, and many of these depend on riparian habitat for food and rest during migration. The loss of riparian habitat most directly affects the 76 species in the passerine order of birds, of which 59 nest in riparian habitat and are predominantly insectivorous.

Forty-five species of mammals in Southern California are associated with riparian habitat.

CHAPTER 5. ECOSYSTEM PROCESSES AND VALUES

5.1 ECOSYSTEM PROCESSES

5.1.1 Primary Productivity

Green plants are distinguished from other living organisms principally by their ability to assimilate carbon dioxide, oxygen, water, nitrogen compounds, and minerals and to synthesize them into organic sugars, starches, and proteins. The total amount of organic matter manufactured by green plants is called the gross primary productivity of an ecosystem. Net primary productivity is the total amount of organic matter manufactured and stored by green plants beyond their own respiratory needs. Primary productivity may be in the form of leaves, woody tissue, fruit, nectar, pollen, or detritus (Billings, 1978; Odum et al., 1984). Determination of the net primary productivity of a riparian forest is complex because calculations must take into account the rapid turnover of short-lived herbaceous plants and the accumulation of productivity of shrub layers and of still longer-lived trees (Whittaker and Niering, 1975).

The major environmental gradient or limiting factor of a riparian system is the availability of moisture. The percentage of winter-deciduous trees and the percentage of large-leaved trees closely follows this gradient from xeric slopes to perennial streams (Whittaker and Niering, 1965; Campbell, 1980). The riparian zone is characterized by vegetation that requires large amounts of free or unbound water, as shown in Figure 42. The leaves and annual increment of woody biomass of riparian trees and shrubs are larger than, for example, those of chaparral or coastal scrub species; thus, net primary productivity figures for riparian vegetation would be expected to be higher than those for drier habitat types, particularly for older, more mature stands. According to Whittaker (Lieth and Whittaker, 1975), the productivity of temperate woodlands and shrublands (excluding deserts) appears to be between 250 and 800 $g/m^2/yr$. There are no productivity estimates for the riparian community in Southern California; however, Holstein (1981) states that California's riparian communities are its most productive because they receive abundant water during hot, cloudless summers which are ideal for maximum photosynthesis.

The primary productivity of green plants serves as a direct energy source for decomposing bacteria and detritivores, which further fragment decomposing plants. These organisms, part of the secondary productivity of a riparian ecosystem, serve, at least in part, as an energy source for a succession of other organisms and are an important component of a rich food web that culminates in large insects, reptiles, birds, and mammals. Biomass produced within the riparian ecosystem can be used entirely within the riparian community, moved to and used in adjacent communities, or used by animals moving between riparian and adjacent communities.

5.1.2 Riparian Vegetation and Stream Ecosystems

Riparian vegetation is important not only within the riparian ecosystem but beyond it to the structure and function of the adjacent stream ecosystem. Some of the major contributions of riparian vegetation to in-stream components are shown in Figure 43, a model developed from a study of Sierra Nevada streams.

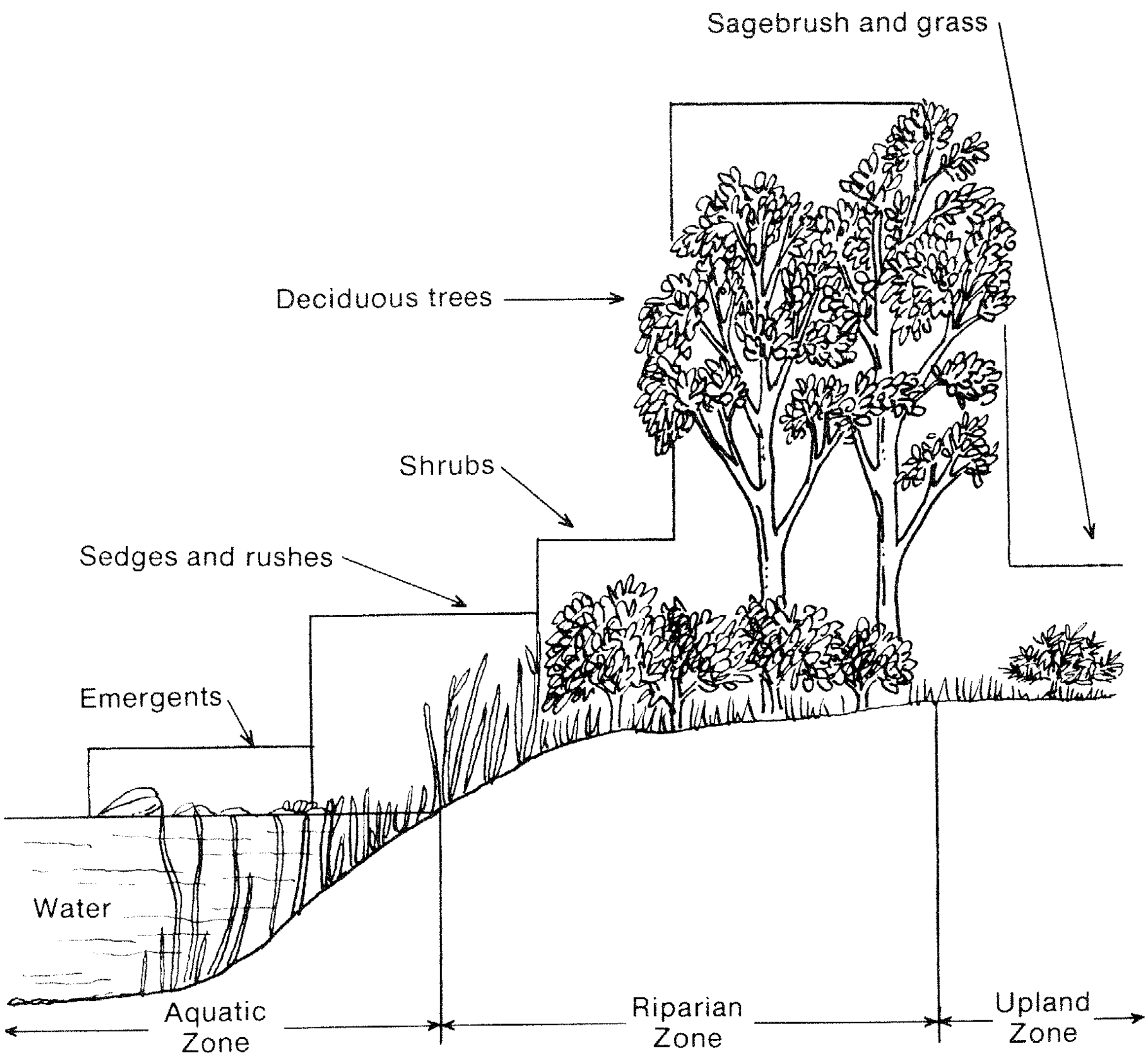


Figure 42. Riparian vegetation requires large amounts of free or unbound water (adapted from Thomas, 1978).

a. Detrital Food Base. Woodland streams derive most of their biological energy from organic material that comes from adjacent terrestrial communities (Knight and Bottorff, 1984; Hynes, 1970). Detritus provided by riparian vegetation is a source of up to 90 percent of the nutrients consumed by instream aquatic communities (Hubbard, 1977; Cummins, 1975; Merritt, 1978; Hart, 1975). Detritus and nutrients from adjacent upland ecosystems (e.g., chaparral and coastal scrub) are recycled through natural processes of fire and flood and transported downstream in the riparian ecosystem (R. Vogl, California State University (Los Angeles); pers. comm.).

The contributions of organic matter from riparian vegetation to stream ecosystems has been appreciated only recently (Cummins, 1974). Natural changes in riparian vegetation and the biotic processing of detritus, among other factors, determine the kinds and abundance of aquatic invertebrates living in streams, from headwaters to the river delta (Hynes, 1970).

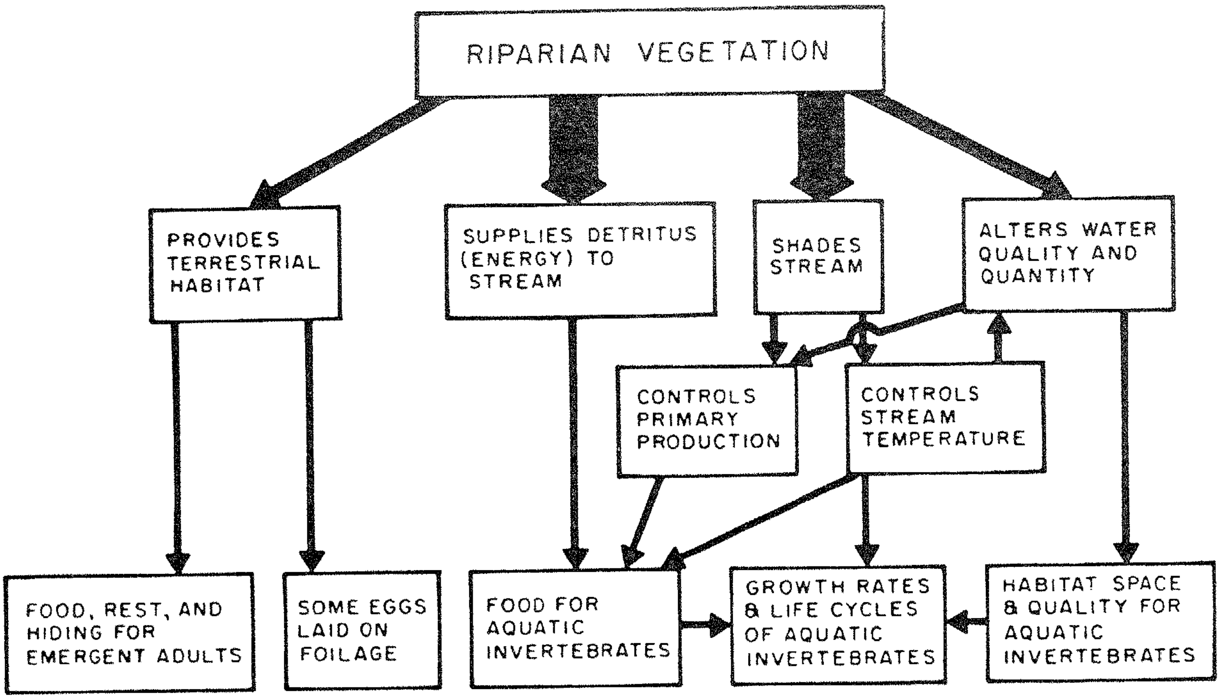


Figure 43. Relationships between riparian vegetation and stream components (from Knight and Bottorff, 1981).

Knight and Bottorff (1984) summarize the role of aquatic organisms in continually processing and transforming organic matter from the time it enters the stream. The process of leaching dissolved organic matter (DOM) from coarse particulate organic matter (CPOM) such as leaves, pollen, and fruit begins once it reaches the water. Fungi and bacteria rapidly colonize organic matter undergoing leaching, and aquatic insects such as stonefly nymphs, cranefly larvae, and caddisfly larvae shred or break down CPOM and are called "shredders."

CPOM is broken down into fine particulate organic matter (FPOM) by the feeding action of shredders and microorganisms, the physical abrasion of stream turbulence, and the fine particles that are eroded from streambed algae or the surrounding watershed. The fine particles are food for organisms known as "collectors," which gather or filter particles from flowing water. A third group of aquatic animals, called "scrapers," have mouth parts adapted to scraping up and consuming algal scum, which also contains microscopic animals. Still other aquatic invertebrates and vertebrates prey on shredders, collectors, scrapers, and each other. The amount, kind, and timing of vegetative additions to the stream and the shading provided by streamside plants will determine, to a degree, which feeding groups prosper at any given site, but, particularly, which species within each feeding group will prosper.

The structure and function of aquatic communities along a river system have been organized into a River Continuum Concept (Cummins, 1974, 1975; Vannote et al., 1980) which involves several stream factors that interact to influence the availability of food for stream animals--temperature, substrate, water velocity, stream morphology, and energy inputs from adjacent terrestrial communities or from sources within the stream. According to this concept, these factors should vary predictably from headwater to downstream and should produce predictable distributions of feeding groups (shredders, collectors, and scrapers) along the continuum. This model should be applicable to streams and rivers in the study area, taking into account the reduced temperature fluctuations, extended periods of leaf fall, and the wet/dry annual cycle common in Southern California.

b. Stream Shade from Riparian Vegetation. Shade created by riparian vegetation is a major factor controlling light intensities reaching algae and macrophytes, particularly in headwater streams, and, therefore, the level of primary productivity in streams. Shade removal has been demonstrated to increase primary productivity and cause algal mats in small streams (Brown and Krygier, 1967, 1970; Brown et al., 1971; Likens, 1970; Graynoth, 1979). Shade moderates stream temperatures, often preventing summer temperatures that may be lethal to invertebrates or fish. Stream water temperature affects numerous stream functions: processing rates of organic matter, chemical reactions and concentrations, metabolic rates of stream invertebrates, and cues for lifecycle events (Knight and Bottorff, 1981). Table 11 provides figures for water temperature changes in small streams caused by removal of riparian vegetation. Studies of clear-cut watersheds show that when riparian buffer strips remain, stream temperatures also remain essentially the same as in untouched watersheds (Brown and Krygier, 1970; Swift and Messer, 1971;

Table 11. Water temperature changes in small streams caused by riparian vegetation removal in relation to undisturbed conditions (from Knight and Bottorff, 1984).

Location	Forest type	Temperature change Summer[a]	Temperature change Winter
Oregon	coniferous	+ 8 (A)	--
		+15 (B)	--
		+ 8 (A)	0
Alaska	coniferous	+ 5 (A)	0
Kansas	deciduous	+ 5 (C)	--
New Hampshire	deciduous	+ 5 (C)	+
		+ 4 (D)	--
West Virginia	deciduous	+ 8 (A)	-2
North Carolina	deciduous	+ 7 (A)	-2
		+13 (E)	--
New Zealand	mixed coniferous and deciduous	+ 4 (A)	-2.5
		+ 7 (B)	--

[a]Summer increase in water temperature based on:
(A) mean monthly maximum water temperatures
(B) instantaneous water temperatures recorded for one year
(C) instantaneous water temperatures recorded for one summer day
(D) mean weekly water temperatures
(E) weekly maximum water temperatures

Graynoth, 1979) and stream macroinvertebrate diversities remain high (Erman et al., 1977).

c. Life Cycles of Aquatic Insects. Vegetation growing adjacent to streams plays an important role in the life cycles of many aquatic insects (Knight and Bottorff, 1981). Some emerge into terrestrial ecosystems as adults with wings for dispersing and searching for mates. Foliage is used for feeding, resting, hiding, and sometimes in mating rituals. Some insects lay eggs on riparian vegetation overhanging the stream so that upon hatching the larvae will drop into the water for the aquatic life stages. With reduced vegetation, the number of niches for insects is reduced, resulting in reduced numbers of species and populations. Insectivorous birds, particularly those feeding on leaf-feeding insects, consequently lose both food supply and cover.

5.1.3 Role of Fire in Nutrient Cycling Between Ecosystems

A vast amount of the riparian habitat of Southern California intergrades with chaparral or coastal scrub communities. Chaparral vegetation is particularly prone to fire because of its dense, contiguous growth and lack of moisture. Often the chaparral community produces an abundance of fuel that accumulates faster than it decomposes because of resistance to decay or climatic factors. These plant accumulations are highly flammable; thus, fire is a regular occurrence under natural conditions and infrequent but inevitable under fire-exclusion policies, particularly near urban areas.

R. Vogl (pers. comm.) suggests that the riparian community serves an important role in fire/flood sequences in Southern California, resulting in energy flows between plant communities. Fires reduce organic matter to a bouyant ash and charcoal. The flotsam component is usually transported in an emulsion that resists burial and assures widespread surface deposition. During winter rains and floods, charcoal and emulsified mineral products are carried into streams, where they are redeposited onto the land by flood waters or carried downstream toward coastal wetlands. Nutrients bound in light, nonwettable fragments of charcoal and ash emulsions are bouyant and remain in the upper layers of flood-deposited sediments, readily available to new plant growth. Nutrients derived from a chaparral community in a fire/flood cycle may remain in the same community or be transported to the banks or floodplain of an adjacent riparian community; to a flooded adjacent coastal scrub, oak, or broadleaved evergreen woodland community; or downstream to a coastal freshwater or saltwater marsh. The riparian corridor thus becomes a kind of circulatory system linking plant communities in this fire/flood model.

In areas where riparian cover has been removed, leaf-litter levels are reduced or eliminated and soils are exposed. As a result, stream sediment loads from erosion are increased and water velocity increases, minimizing the energy-transfer potential of fire/flood cycles. Nutrients may then be transferred in fast-flowing waters downstream and lost in the ocean.

No energy flow studies exist for the riparian habitat of Southern California. The model presented in Figure 43 is hypothetical and the size of the energy flows is unknown. In years of heavy, gentle rain, the contribution of an adjacent upland ecosystem to the riparian system is greater than in dry years, when there is little movement of nutrients, detritus, and leaf litter. In years of flash floods, material and nutrients move though the system too quickly to be made available to riparian organisms (R. Vogle, pers. comm.).

5.2 RIPARIAN HABITAT VALUES

5.2.1 Water Quality and Quantity and Stream Maintenance

The riparian ecosystem, with its linear form, plays important and little-recognized roles in tying together adjacent ecosystems: in nutrient recycling, as a source for seed dispersal, and as corridors for wildlife moving between ecosystems. The riparian ecosystem enhances the habitat value of adjacent systems. Where riparian vegetation is removed, entirely or in part, habitat values are diminished. This is particularly true for the lush understory growth, so frequently ignored or cleared as a nuisance to man (Odum, 1978).

Riparian vegetation plays a major role in downstream water quality. It stabilizes streambanks by reducing the erosive energy of rainfall and of flowing water. Trees, shrubs, herbs, and their leaf litter all cushion the force of falling raindrops and thus reduce the amount of sediment carried into streams. For a given amount of precipitation the quantity of sediment eroded from plowed land is 80 times that from grassland (Leopold et al., 1964). In areas undergoing rapid urbanization and subjected to poor watershed planning and careless construction techniques for roadways and housing projects, erosion rates may be several thousand times as great as those found in an undisturbed forest (Bormann and Likens, 1977; Jones, 1982).

In addition, the shading effect of riparian vegetation affects water quality by moderating water temperatures and thus the kinds and rates of chemical reactions. Organic matter in the soil retains moisture and influences pH and ion exchange (Leopold, 1964). Vegetation also plays an important role in stream maintenance, protecting streambanks from watercourse and surface runoff erosion by binding the soil with extensive root masses, by maintaining soil porosity, and by impeding the rate of surface runoff through the accumulation of leaf litter (Knight and Bottorff, 1981). In these ways the severity and frequency of minor floods are reduced (Jones, 1982).

Ground-water basins in Southern California are in arid valleys, while most precipitation occurs in the mountains. Natural recharge of ground-water basins occurs mainly by percolation of water from streams after they enter the permeable alluvial soils of valleys. The interaction of riparian vegetation with associated streams is critical to this process of ground-water recharge. Vegetation promotes maximum infiltration of rainfall by creating a loose organic soil, ready to absorb either sparse rainfall or the occasional flood. During floods, riparian vegetation reduces the velocity of moving water, causing it to remain in contact with soil banks and floodplains for longer periods of time and enhancing the process of ground-water recharge (Bormann and Likens, 1977). Since the roots of riparian trees can be located in perennial ground-water or in the capillary fringe above the water table, they reduce ground-water levels through transpiration, and, in dry areas, water yields have been increased by the removal of riparian vegetation (Ohmart and Anderson, 1977). To determine the best management practices for a given site, close examination of vegetation and soils is required.

5.2.2 Habitat for Wildlife

The riparian plant community in Southern California covers less acreage than other communities such as chaparral or oak woodland, but it receives disproportionately heavy use by animals (Beidleman, 1948, 1954; Dumas, 1950; Wooding, 1973; Bottorff, 1974; Kelly, 1975; Kirby, 1975; Gaines, 1977; Hubbard, 1977; Hinschberger, 1978; Jahn, 1978; Ohmart and Anderson, 1980). Much of the information in this chapter is based upon work carried out in riparian systems outside the study area, since almost no documentation of the above statement has been undertaken in Southern California. In an unpublished report, Warner points out that there is a growing body of information regarding previously unrecognized functions and values of riparian habitat, but predicts that it would be a decade or more before all of the major values of this complex dynamic ecosystem could even be identified. The ninth annual report of the U.S. Council on Environmental Quality (1978) states that "no ecosystem is more essential than the riparian system to the survival of the nation's fish and wildlife." Johnson et al. (1977) calculate that western riparian ecosystems contain 42 percent of the mammal species of North America, 38 percent of the reptiles, and 14 percent of the breeding birds. Hubbard (1977) states that 75 species of fish of the southwest are dependent on riparian ecosystems.

While there are numerous reasons why riparian habitat is important to wildlife, the full list of values does not apply to each stream or watercourse. The size of the water source, the physical parameters of individual riparian zones, the diversity of vegetation present, and the extent of human alterations all affect the quality of riparian habitat. The following sections summarize known attributes of riparian habitat important to wildlife.

5.2.3 Availability of Water

Water is of basic importance to wildlife, along with food and cover, particularly in Southern California, where it is rainless for much of the year. Riparian habitat usually offers water, at least for much of the year, and some riparian habitat offers food and cover as well.

The microclimate of riparian zones, particularly those rich in understory vegetation, is different from that of surrounding upland communities because of increased humidity, a higher rate of transpiration, and more shade (Thomas, 1978). Many wildlife species are attracted to this microclimate and some are dependent on it. Insect populations tend to be high, and birds are greatly attracted to the safety and steady food supply found here. Mule deer (Odocoileus hemionus) spend a disproportionate amount of time in such areas because of the presence of cover that helps maintain physiological homeostasis, a condition where energy expenditure is minimized (Thomas, 1978).

5.2.4 Migratory Corridors

Riparian zones along rivers and streams serve as forested connectors between habitats. Wildlife uses such riparian zones for cover while traveling across otherwise open areas. Small mammals and birds use riparian dispersal routes to scatter from their original habitats as a result of population pressures or food or water shortages. Riparian zones provide cover, food, and water during such movements (Figure 44). Riparian zones along intermittent and permanent streams and rivers provide migration routes for a variety of wildlife, including lizards (Schoenherr, 1976), birds, bats, and deer (Thomas et al., 1978). Deer frequently use streams as travel corridors between feeding ranges. In more urban areas, the remnants of riparian vegetation along a neglected creek often provide the only refuge for wildlife (Kennedy, 1977).

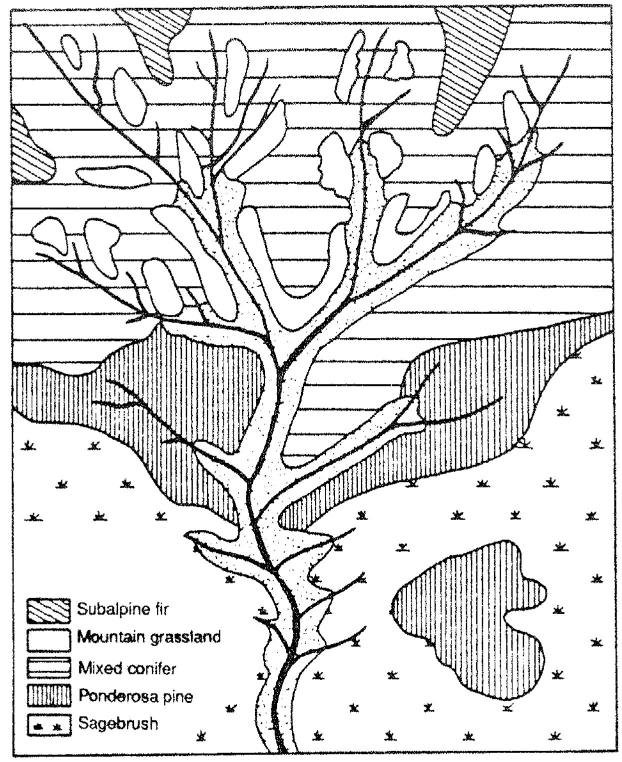


Figure 44. Riparian zones along rivers and streams serve as corridors between habitat types, providing cover, food, and water as animals move from one location to another (from Thomas, 1978). Though the diagram illustrates habitat in the Rocky Mountains, the riparian zone provides the same type corridor in Southern California.

5.2.5 Riparian Habitat Dependency of Aquatic Insects

Most aquatic insects are either indirectly or directly dependent on riparian vegetation at some stage in their life cycle (Erman, 1981). Riparian systems affect the quality of stream habitat upon which aquatic insects depend by producing shade and maintaining cool summer stream temperatures, by providing leaf fall, and by preventing soil erosion. The smaller the stream, the greater is the effect of the riparian system on it. In small streams in upper watersheds, terrestrial leaf litter is an important part of the diet of aquatic insects; farther downstream other insects depend on organic matter chewed and egested by those upstream (Cummins, 1973).

Studies of the feeding habits of aquatic insects have shown that many are omnivorous and that food needs change with developmental stages (Chapman and Demory, 1963; Winterbourn, 1971; Mecom, 1972; Anderson and Cummins, 1979; Erman, 1981). An insect that exists on algae produced within the stream in its early stages may later shred decaying leaves from the riparian zone and later still become carnivorous (Erman, 1981).

The second aspect of riparian use by aquatic insects is that their terrestrial stages can be divided into five areas: feeding; case-building (in Trichoptera); pupating on land along stream edges and banks or in decaying shoreline trees or stumps; emergence and mating, using vegetation for resting or as mating platforms; and egg-laying, usually on overhanging vegetation so eggs or newly hatched larvae drop into the water (Erman, 1981).

5.2.6 Riparian Habitat Dependency of Fish

Though fish are not usually considered part of a riparian community, they interact with and are dependent on this community in a number of ways (Nunnally, 1978; Baltz and Moyle, 1981). They feed on terrestrial insects, use overhanging vegetation as cover, or use flooded vegetation for spawning. Nutrient recycling and the effect of riparian vegetation on water flows and temperatures are also important to fish habitat. The most important physical parameters for fish are stream depth, current velocity, substrate composition, cover, and temperature. All of these change when the riparian community is altered because the riparian system ties together aquatic and terrestrial components through energy exchange, interaction with flow regimes, and impact on temperature regimes (Baltz and Moyle, 1981). In addition, spawning success is adversely affected by increased sediment loads (Cordone and Kelley, 1961).

5.2.7 Riparian Habitat Dependency of Birds

Riparian habitat, with its lush plant understory, thermal cover, and special microclimate, supports more species of birds than any other habitat type in California (Miller, 1951) and is well known for the abundance and diversity of its bird fauna (Gaines, 1977). The extensive loss of riparian habitat in Southern California has caused a rapid decline in several bird species (Remsen, 1979). Breeding populations are particularly important because they include species that occur in virtually no other California habitat (Holstein, 1981). Miller (1951) delineated 21 plant communities in the State and listed the breeding birds for each; there were 75 species nesting in riparian habitat; in montane forests, the habitat with the next highest number of species, there were 70. Gaines (1977) has shown that many of these birds are insectivorous foliage-gleaners that winter in tropical forests, habitat with high net productivity. Insects, which are primary consumers, would be expected to increase in abundance with increasing warmth and primary productivity. Cody (1978) found that insect biomass does, in fact, peak in the spring and fluctuates with primary productivity throughout the year in California upland vegetation.

Pequegnat (1951), in his study of the biota of the Santa Ana Mountains, noted that in oak woodlands 75 percent of the birds were resident species and only 20 percent were summer breeders; in streamside vegetation only 35 percent were residents and nearly 60 percent summer visitors. He attributed this discrepancy to differences in the availability of food. The huge insect populations in spring in riparian habitat create a niche for migrants to use for their brief nesting period. No other class of vertebrates has a large component of migrants that can exploit this seasonal food source. Holstein (1981) found that bird abundance appears to be related to community productivity, suggesting that riparian bird populations would be augmented relative to upland habitats when contrasts between drier upland and moister riparian productivity are the greatest. Such contrasts occur when perennial streams bring water to semiarid lands such as those found in the study area.

Riparian zones are usually dominated by deciduous vegetation that provides one type of habitat during the full foliage of summer and another following winter leaf-fall. In a study of the lower Colorado River, Anderson and Ohmart (1977) determined that bird usage and requirements of riparian habitat varied seasonally and that dense vegetation is more important in the early summer than at other times of the year. They found that winter residents may have larger populations and be more specialized in habitat use than local populations of permanent residents. They suggest that since winter requirements are different from, but as important as, breeding requirements, they should receive at least equal attention, particularly in view of the greater specialization of winter migratory birds.

The dramatic contrast between a riparian plant assemblage and one from a drier surrounding upland community adds to the structural diversity of the area (Jain, 1976). Open wet meadows or groves of deciduous trees around seeps provide habitat edges with sharp contrasts, particularly when they are surrounded by drier grasslands or shrublands. The linear shape common to riparian zones maximizes the development of habitat edge which is so important to wildlife, particularly birds (Bottorff, 1974; Patton, 1975). Where streams flow through canyons, the canyon walls combine with the riparian zone to form a unique habitat complex. Many vegetative strata can be exposed in stairstep fashion, often of contrasting form (deciduous vs. evergreen; shrubs vs. trees), which provides diverse nesting and feeding opportunities for birds and bats (Figure 45). The association of particular birds with distinct layers of vegetation has been repeatedly demonstrated (Thomas, 1978).

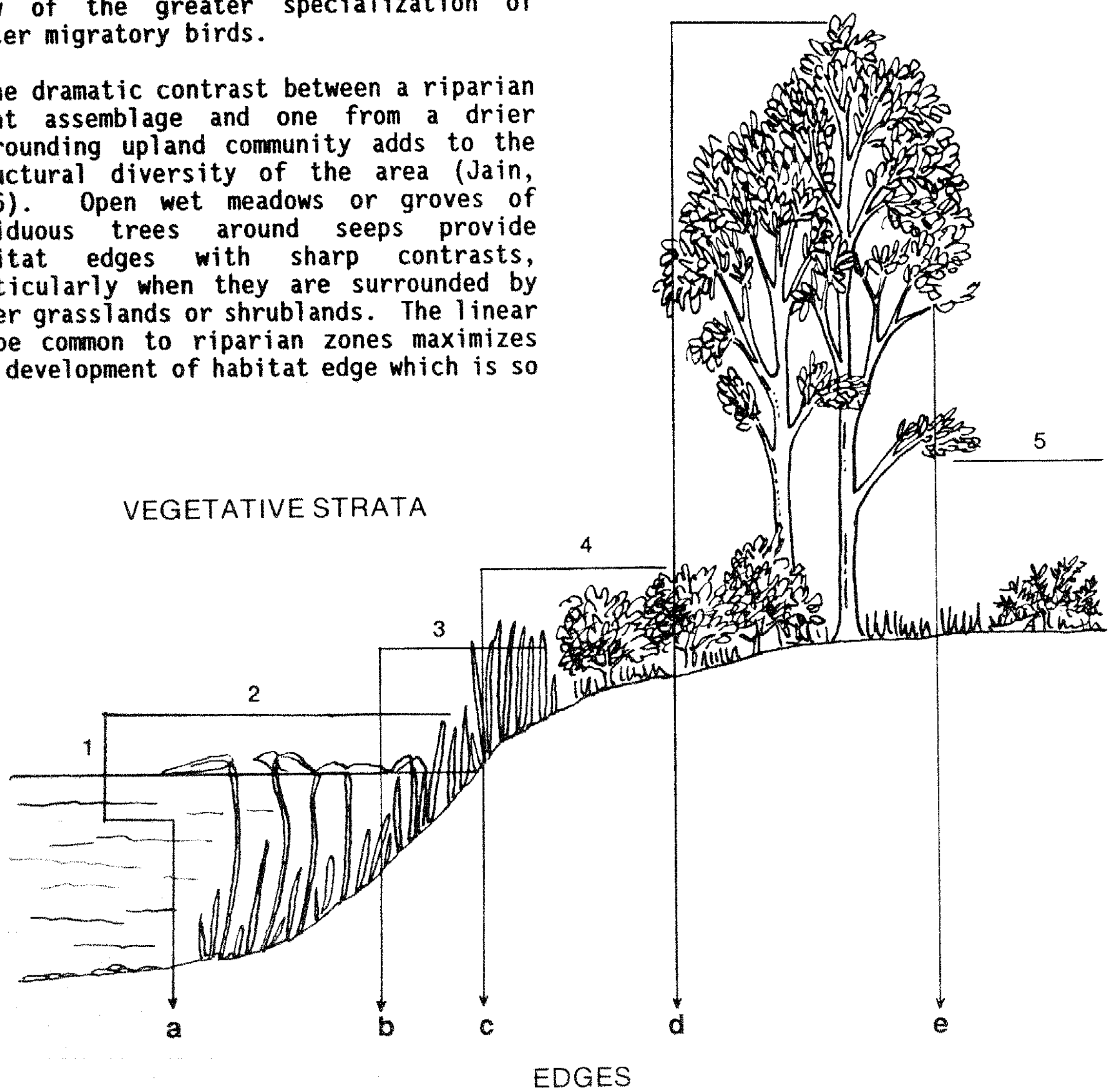


Figure 45. Riparian zones have high numbers of strata levels and edges; five strata levels (1-5) and five vertical edges (a-e) are shown (adapted from Thomas, 1978).

The degree of disturbance of riparian habitat is important, particularly where the understory is removed or altered. Where escaped exotics are invasive and dominant, habitat becomes less valuable to wildlife. In a study along the Santa Clara River, 24 species of birds were observed in a stand of riparian woodland trees with an undisturbed understory, in contrast to 6 species observed in a similar stand of riparian woodland trees with a disturbed understory (Smith, 1979). Nests in the open are more susceptible to predators, inclement weather, and other environmental factors (Best and Stauffer, 1980).

Alteration of rivers and streams has almost invariably resulted in loss of wildlife habitat value. Ohmart and Anderson (1978) studied avian use of ten freshwater habitat types along the lower Colorado River: river below dam, old river channel, oxbow left by river-straightening, unchannelized river with adjacent riparian vegetation, <u>Phragmites</u> marsh, dense cattail marsh, moderately dense cattail marsh, bulrush marsh, reservoir, rip-rapped channelized river, and unchannelized river with adjacent canyon walls. There were consistently higher numbers of birds in the first seven areas, which represent relatively undisturbed sections of the river. Unusually heavy use of the old river channel was demonstrable for several months of the year; moderately dense cattail marsh showed the greatest species diversity.

The interface between riparian and agricultural systems supports a large number of bird species and individuals because it offers a variety of food and structural resources that are especially apparent in winter (Emmerich and Vohs, 1982). Anderson et al. (1984) suggest that such an interface can be used effectively to mitigate loss of natural habitat by interspersing agricultural lands with native vegetation. This, of course, would not compensate for loss of habitat for riparian species of birds such as the yellow-billed cuckoo or the willow flycatcher. Gaines (1977) cites reports that attribute the decline of riparian birds to the brood parasitism of the recently introduced brown-headed cowbird, but notes that its introduction to Arizona occurred before a decline in riparian avifauna. Wauer (1977) cites the linkage of the cowbird with the virtual extirpation of the riparian and insectivorous least Bell's vireo from California and Arizona, but notes that these species coexist in the less agricultural Rio Grande area of Texas. Holstein (1981) suggests that the massive quantities of insecticides used in agricultural areas adjacent to riparian corridors should be investigated for impacts, particularly on the breeding success of insectivorous species.

Invasion of exotic plants has usually diminished the quality of riparian habitat for birds. On the lower Colorado River, riparian birds show a strong preference within the habitat for two plant communities: cottonwood/willow and honey mesquite, and eschewed the introduced salt cedar (Meents et al., 1981). Clearing of salt cedar from heavily invaded riparian areas resulted in increased use by birds (Anderson and Ohmart, 1981).

5.2.8 <u>Habitat for Mammals</u>

Unlike birds, which are primarily predators, mammals are both predators and prey. Small rodents form the principal prey group; the California mouse, dusky-footed woodrat, and others are food for the carnivores--coyote, ringtail, long-tailed weasel, bobcat--plus hawks, owls, and snakes. Some of the carnivores are omnivorous, such as the black bear, which feeds on roots, fruits, nuts, grasses, insects, and small rodents--and garbage. The raccoon has an even more varied diet, including crayfish, turtles, frogs, birds, eggs, and fruit, as well as insects and rodents (Ingles, 1965).

Several orders of mammals are primarily insectivorous, notably the shrews and moles (Insectivora) and bats (Chiroptera). Their prey is different; the shrews and moles are fossorial and forage below or on the ground, while bats are strictly aerial feeders.

Pequegnat (1951), in his study of the biota of the Santa Ana Mountains, noted that the number of mammals in riparian habitat was small compared with their numbers in chaparral and sagebrush communities. Several recent studies, however, report very different findings. Of the eight habitats Bleich (1973) examined on the Fallbrook Naval Annex, the most diverse rodent fauna present was in a streamside woodland community, although larger numbers were found in the coastal sage community. In a more recent study on the Santa Rosa Plateau, capture rates were better in riparian woodland than in chaparral (R. Zembal, USFWS, Laguna Niguel; pers. comm.).

In a USFWS study (Zembal, 1984b) on the Santa Margarita River, the highest capture rates and greatest species diversity were in riparian habitats--far above values found in coastal scrub habitat, usually considered the most productive for rodents. The diversity and abundance of small mammals on the Santa Margarita River appeared to be related to the near-ground habitat structure; the more diverse habitats had larger and more diverse rodent populations. Riparian habitat, with its abundant cover in the form of litter, low-growing vegetation, and structural relief, afforded small rodents both food and water, and was the most diverse of the habitat types along the river.

Larger species of mammals--deer, bighorn sheep, mountain lion, and bear--use streams and adjacent riparian habitat for water and forage. Availability of water, forage, and thermal cover is critical for their survival, even though they are not primarily associated with riparian habitat. Along the Santa Margarita River, bedding pads where deer take cover are abundant, particularly in the summer, when deer seek relief from the heat and browse on green vegetation near the water (Zembal, 1984b).

5.3 POSITIVE VALUES FOR PEOPLE

5.3.1 Air and Water Quality

Inherent in the riparian ecosystem are beneficial values for man that have not been adequately recognized. Riparian habitat is capable of improving air and water quality through its ability to filter pollutants. Riparian vegetation removes particulates from the air by direct adsorption onto leaf surfaces and gases by absorption into leaves. Chemical detoxification of sulfur dioxide, chlorine, and carbon monoxide can then occur (one acre of trees can remove 3.7 tons of sulfur dioxide and 12.9 tons of dust per year) (Bormann, 1977). Nitrous oxide, a common pollutant in automobile exhaust, is absorbed by vegetation and soil organisms and thus restricted from entering ground and surface water supplies. Other pollutants removed from water as it percolates through soil include zinc, copper, nickel, lead, manganese, some radioisotopes, and pesticides. Substantial quantities of nutrients move between riparian vegetation and the soil; however, little escapes into the watercourse, except during periodic flooding. If the vegetation is disturbed or removed, the nutrient-holding capacity of the system is reduced, nutrients leach out of the soil, and pollution of runoff water results.

Currently, some land managers favor the maintenance of natural stream channels as the best management practice in areas of limited water resources (R. Vogl, pers. comm.). An equilibrium can be reached by permitting a stream to meander and by stabilizing its banks with native vegetation. The results produce less erosion, higher stream productivity, and better water quality than in streams altered and channelized. Ground water is recharged more efficiently because water can percolate more slowly and the rate of runoff is slowed (Karr and Schlosser, 1978).

5.3.2 Benefits to Agriculture

Although riparian vegetation is frequently removed to reduce transpirational losses (Robinson, 1985), riparian barriers can benefit agricultural landowners. By providing a natural fence, riparian vegetation can prevent trespassing and potential vandalism of property. Riparian habitat also supports predators of rodents and insects that are agricultural pests. Birds of prey require perching sites where they hunt. Most riparian bird species feed exclusively on insects and thus provide pest control for those who allow their riparian forests to remain (McFarlane, 1976; McNichol, 1982). In addition, because of the high soil moisture and soil quality adjacent to streams, there is a small potential for sustained yields of timber for firewood or specialty hardwood production, such as the native black walnut (R. Vogl, pers. comm.).

5.3.3 Aesthetic and Recreational Values

Many direct benefits accrue to local residents from the preservation of riparian habitat and wildlife. Some of the same qualities that attract wildlife, such as water and shade, also attract people seeking recreation (Figure 46). The vegetation canopy can act as a visual screen and a noise buffer to create a feeling of wilderness, even though a busy freeway may be just over the adjacent levee. The linear parks in riparian corridors are some of the most popular in Sand Diego County. Picnicking, camping, nature study, fishing, hunting, hiking, canoeing, and photography are all activities enhanced by the quality of riparian habitat. However, the value of parkland for wildlife is almost always diminished when the riparian understory is removed to open up the area for trails, picnic tables, rest rooms, campsites, and law enforcement patrol routes, particularly if the ensuing use is heavy (Heberlein, 1977; Lewis and Marsh, 1977; Schmidly and Ditton, 1978).

5.4 HUMAN IMPACTS ADVERSE TO THE RIPARIAN ECOSYSTEM

The general topic of human impacts and disturbance in riparian systems has been well covered (Carothers, 1977a; Schmidly, 1978). There is little or no riparian habitat in Southern California that has not been affected to some degree by man's activities. Some activities, such as stream channelization, eliminate all riparian habitat and wildlife values. Other activities cause severe disturbance.

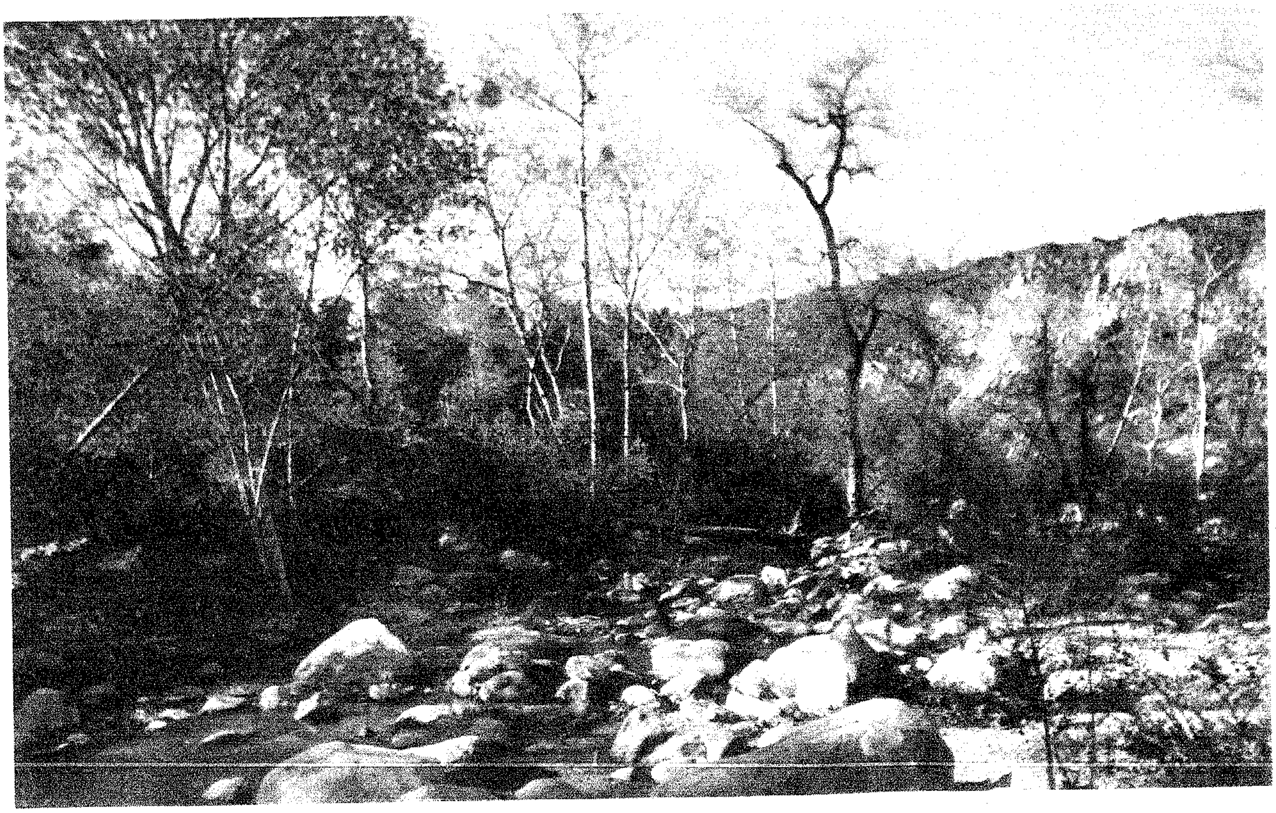


Figure 46. The Wilderness Gardens Preserve along the San Luis Rey River protects a remnant of riparian habitats.

5.4.1 Sensitivity to Disturbance

In Southern California, riparian zones occupy small areas and are particularly vulnerable to severe alteration. More mature stands of vegetation provide more distinct strata and ecological edges and thus a greater diversity of habitats. Disturbance usually reduces the structural and species diversity of the plant community, which in turn reduces the diversity of habitats for wildlife (Figure 47). Disturbance also alters the microclimate of the riparian corridor (Ames, 1977). Changes in canopy cover can alter water quality, quantity, and temperature with dire consequences for the fauna (Boussu, 1954; Collings and Myrick, 1966; Tuinstra, 1967; Gunderson, 1968; Campbell, 1970).

The amount and size of sediments in stream substrates is a result of many processes, some of which can occur in the riparian zone. Sediment loads may be increased from such human activities as logging, clearing for development, agriculture, and road building or from such natural causes as landslides. Table 12 shows the change in suspended sediment in a watershed after logging.

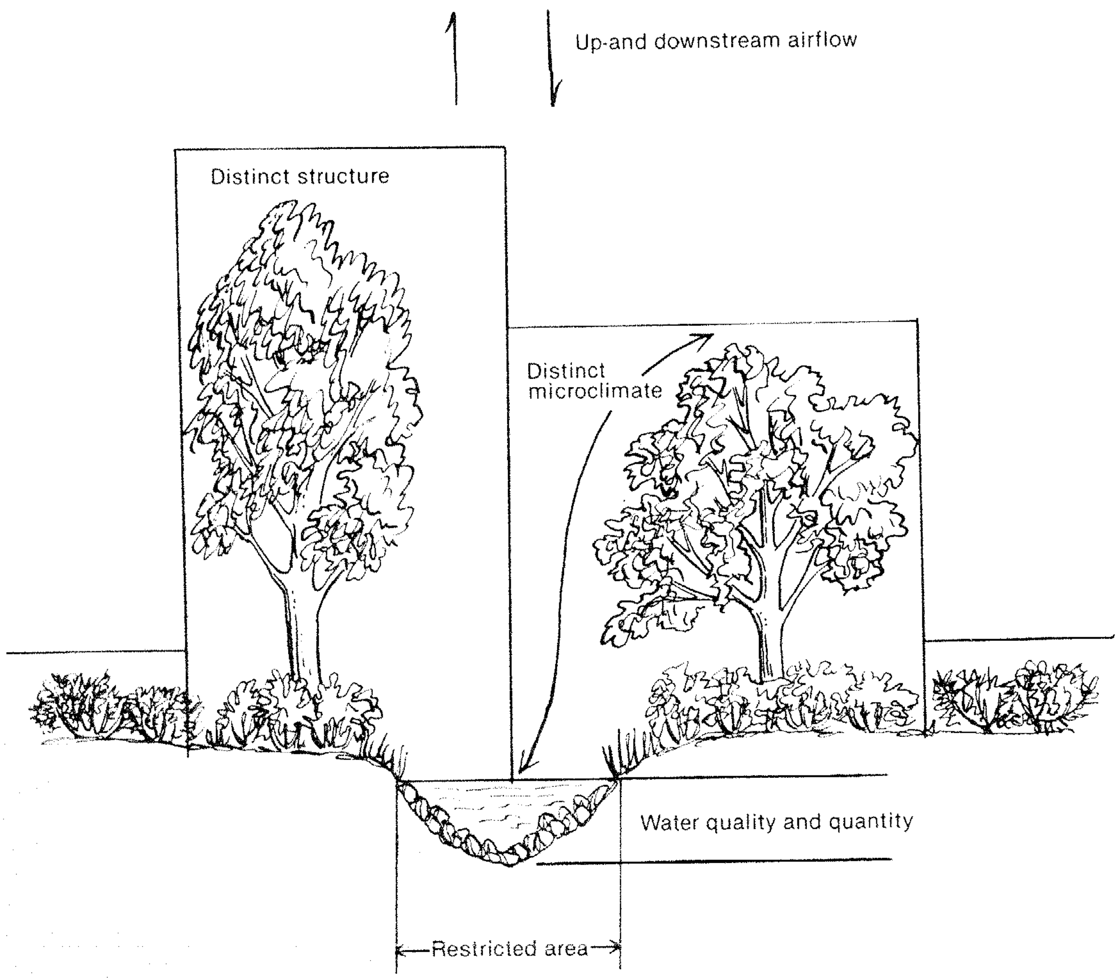


Figure 47. Riparian zones must be considered delicate due to the combination of restricted area, distinct microclimate, vegetative structure and composition, and water quantity (adapted from Thomas, 1978).

Table 12. Average percentage increase in suspended sediment in the Alsea, Oregon, watershed 7 years after logging.

Method	% Change
Control	0.1
Clearcut with buffer strip	54.0
Clearcut	205.0

How fast sediment loads are moved through the stream depends on such factors as slope, instream sediment traps, and the frequency of large storms. It may easily take 5 years for a pulse of sediment to flow completely through a stream system (Dunne and Leopold, 1978). Thus the amount of sediment in a stream at any given moment is the summation of all the land-use activity adjacent to the stream and the weather patterns that have prevailed in the stream basin for several preceding years (Mahoney, 1981).

Buffer strips of vegetation left along streams affected by human activities have been shown to help protect the integrity of a stream system. Figure 48 shows changes in transportable sediment in narrow buffered and nonbuffered streams. Vegetation is important not only in protecting the stream immediately adjacent to it, but also in protecting the biota downstream from excessive sediment pulses (Cordone, 1961). Downstream benefits usually are not included in cost-benefit analyses of preserving buffer strips adjacent to streams; they need to be more realistically evaluated (Mahoney and Erman, 1981).

As shown in Figure 49, proliferation of domestic or agricultural wells adversely affects riparian trees growing on floodplain terraces by lowering water tables from levels that once supported their large growth.

5.4.2 Recreational Activities

Stream courses and associated riparian vegetation and wildlife sometimes are drastically impacted by recreational use when they are readily accessible to a large urban population, as in the San Gabriel Mountains. Dirt bikes use the stream

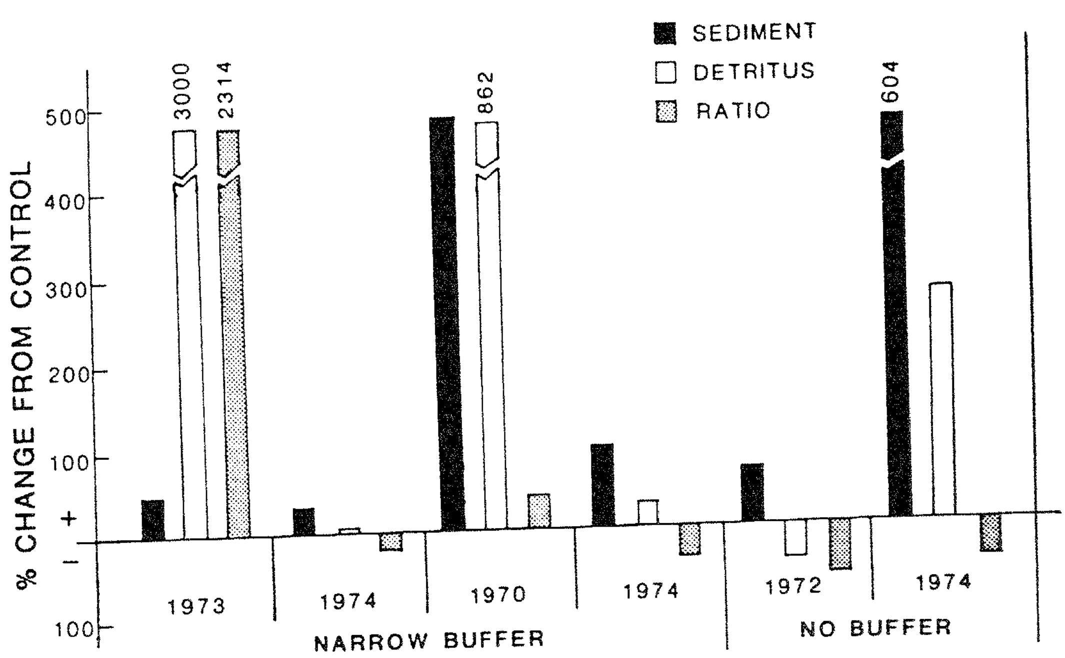


Figure 48. Percentage change from control in transportable sediment, detritus, and the detritus/sediment ratio in narrow buffered and unbuffered streams in Northern California (dates are year of initial logging; from Mahoney and Erman, 1981).

Figure 49. Cottonwood trees are adversely affected by lowered water tables in the San Jacinto River floodplain.

channels as trails. Trash, graffiti, and downed trees are everywhere. Human intrusion resulting from permitted recreational shooting has devastated the riparian habitat at Lytle Creek. Streams close to picnic grounds are often extensively degraded (Caruthers, 1977). Activities around campgrounds contribute to local soil compaction. Automobiles and septic systems contribute toxic runoff. People can be destructive to vegetation, and the understory usually suffers most. Abandoned pets, if they survive, become predators on native populations of rodents, birds, and other wildlife. The disturbance of campground sites adversely affects breeding birds (Aitchison, 1977). Some campgrounds, such as South Fork on the upper Santa Ana River, have had only a modest impact on the riparian habitat, while at Lytle Creek in the San Gabriel Mountains, damage has been severe.

5.4.3 <u>Gravel Mining</u>

Most of the rivers and larger creeks of Southern California, except those deep inside national forests, have been used for gravel-mining operations, which severely disrupt the streambed at the dredge site, increase sediment loads downstream, and alter ground-water tables. Fish populations, when present, decline and disappear in streams where gravel is mined. Access roads for trucks, dredges, and other equipment cause loss of vegetative cover, disturbance to wildlife, and soil compaction. Examples are common throughout the study area, but are most readily seen along the Santa Clara River in Ventura County and San Juan Creek and the San Luis Rey River in San Diego County (Figure 50).

5.4.4 <u>Water Impoundments</u>

Water impoundments result in three major changes to the downstream physical environment: alterations in waterflow regimes, shifts in erosion and deposition patterns, and changes in water temperature fluctuations, with resultant impacts on riparian and instream biological communities. Seeds of riparian species such as willow and cottonwood are timed to be

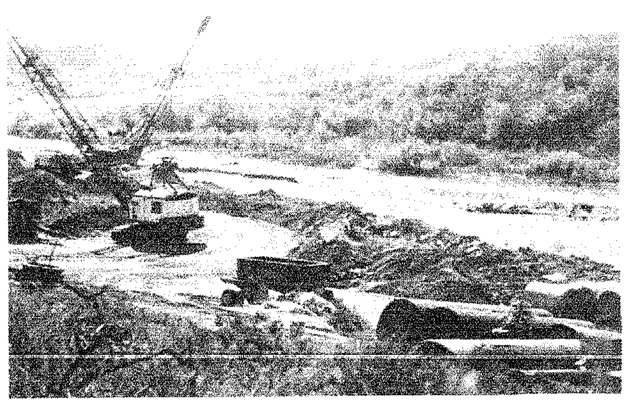


Figure 50. A gravel operation on the San Luis Rey River (photograph by A. Sands).

released as rivers recede. Seed viability is short-lived, and successful germination and seedling establishment are dependent on freshly deposited alluvium (Fenner, 1984). Studies conducted before and after construction of the Glen Canyon Dam on the Colorado River show that, prior to construction, the river overflowed its banks during annual floods and created backwater and marshy areas, habitats critical as breeding areas for fish and other organisms (Carothers and Nolan, 1982). These natural high/low flow patterns no longer occur because of controlled discharges from the reservoirs resulting in reductions in numbers and abundance of several species.

Along with altered waterflows are drastically reduced downstream sediment concentrations, since most sediments and associated nutrients are retained behind the dam. These nutrients, normally carried by annual floodwaters, are thus no longer available for recharging soils. The bottom and banks of the river will eventually be scoured free of sand and silt, leaving boulders, cobbles, and gravel in the riverbed. Changes in light penetration of the water column and of the substrate will provide a different habitat, suitable for different organisms. Releases of reservoir water have a narrow range of temperature fluctuation, which further alters habitat, particularly for those whose reproductive behavior is cued to temperature fluctuations. The presence of year-round flows can cause increases of riparian vegetation and expand habitat for birds, rodents, reptiles, and amphibians. On the Colorado River, least Bell's vireo and several other small birds and reptiles have increased in population as a result of increases in breeding habitat (Carothers, 1982). Water impoundments affecting streams and rivers in the study area are smaller in scale, but the impacts are similar.

5.4.5 Agriculture and Grazing

Most of the floodplain or river-bottom land in Southern California has been converted to urban, grazing, or agricultural uses. Citrus groves along the Santa Clara River extend from the bluffs to the edge of the river course, covering the entire floodplain for miles between Interstate 5 and the ocean. Riparian animals are restricted to a narrow strip of vegetation at the river's edge. Increasingly, as a result of favorable tax benefits, avocado groves are being planted on steep hillsides, particularly in San Diego and Riverside counties. These orchards are particularly devastating because of the extensive disruption of native soil-binding vegetation and the resultant silt loads. In some of these new avocado groves, future rains will carry unprecedented sediment loads to the streams.

Grazing of the forest may lower reproduction densities in floodplain areas. When grazed, forests are kept clear of ground cover and young trees. When grazing is excluded, regrowth of a thick understory may also prevent seedlings from becoming established. Thus, grazing could be responsible for the lack of establishment of certain age classes in the flood-induced age structure through seedling elimination (Strahan, 1981).

5.4.6 Urbanization and Road Building

Extensive areas of flood plains have been converted to housing and other urban developments with a concomitant loss of natural cover. The need for flood control inexorably accompanies such development. In both urban and suburban planning, the economic benefits of preserving riparian habitat are often ignored (Figure 51). Following loss of this habitat, repair of erosion damage is costly and technically difficult in Upper Newport Bay in Orange County and the lagoons of San Diego County. In addition, it is not the developer but the public that usually pays the long-term costs of stream repair and erosion control. Rarely have there been attempts to preserve riparian habitat in the process of flood-control projects. The lower flood plains of the Los Angeles, San Gabriel, and Santa Ana Rivers, all channelized by 1930, show how channelization of river courses may eliminate most riparian features.

Road construction can have major adverse impacts on riparian habitat. Roads in stream and canyon bottoms not only destroy the habitat on which they are built, but alter micro-climates, as shown in Figure 52. Roads introduce disturbances from people, pets, and vehicles; they compact soils; and they impact water quality

Figure 51. A cement apron replaces the riparian understory in a development in Temecula.

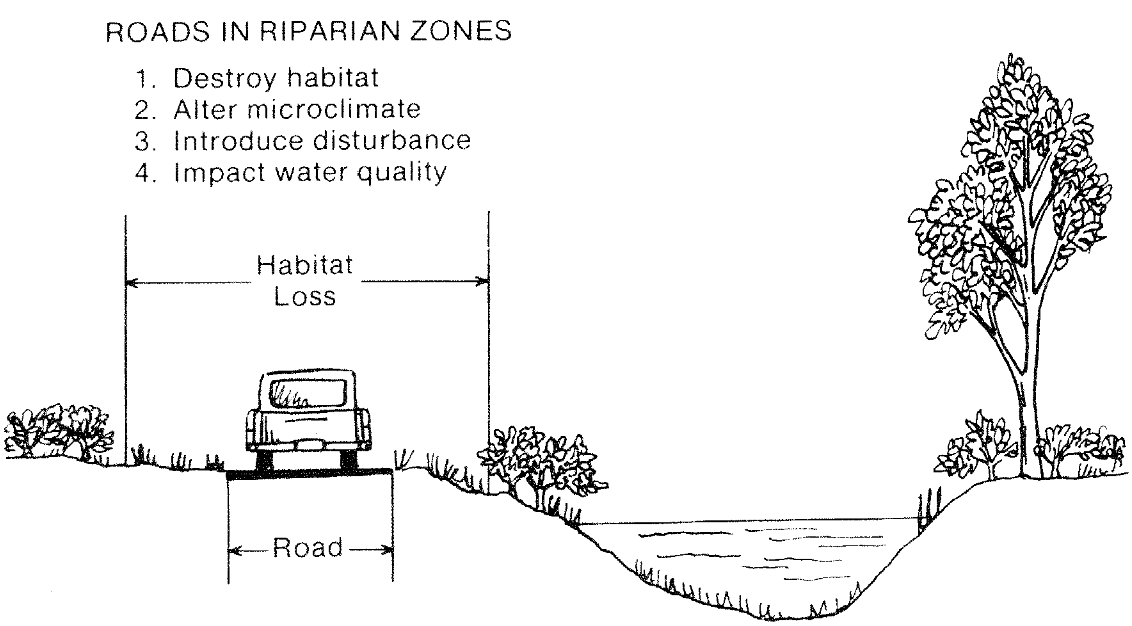


Figure 52. Road construction in riparian zones reduces their usefulness as wildlife habitat by altering vegetative structure and microclimate, reducing the size of riparian zones, disturbing wildlife, and lowering water quality (adapted from Thomas, 1978).

through siltation from road construction (Thomas, 1978).

5.5 SUMMARY

In summary, vegetation of the highly productive riparian plant community is used within the riparian community or in adjacent stream systems. The riparian plant community serves an important role in fire/flood sequences in Southern California in nutrient recycling. Riparian habitat protects water quality and quantity; it provides wildlife with water, shade, and migratory corridors; it maintains natural barriers and habitat for pest predators for agriculture; and it offers aesthetic and recreational opportunities.

Remaining riparian habitat and downstream areas are sensitive to disturbance. Adverse human impacts result from such activities as clearcutting to stream borders, gravel mining, water impoundments, overgrazing, urbanization, recreation, and road building.

CHAPTER 6. GOVERNMENT JURISDICTIONS AND RELATIONSHIPS

6.1 INTRODUCTION

Although many laws and regulations affect riparian habitat, generally they fail to protect this ecosystem. Federal and State laws have created overlapping jurisdictions and rarely set minimum standards. In addition, budgetary problems result in weak monitoring and enforcement. Local governments, plus hundreds of independent special districts, are largely unacquainted with the management of watersheds or riparian resources (Kusler, 1978; John Muir Institute, 1979; Shute and Mihaly, 1981). The result is a lack of statewide or locally coordinated programs to protect the riparian ecosystem.

6.2 FEDERAL GOVERNMENT

6.2.1 Federal Laws

a. Clean Water Act. Section 404 of this act (PD 92-500) authorizes the Corps to regulate the discharge of dredge spoils or fill into the waters of the United States. This has been interpreted by court decisions and regulations to mean navigable waters, lakes over 10 acres, and streams even beyond their headwaters (the point where the flow is 5 ft^3/s). A NWF vs. Marsh settlement in 1984 caused the Corps to revise their regulations and increase their responsibilities in wetlands above the headwaters of streams. More directly applicable to riparian systems is Section 208 of the act, which has led to regional "non-point" pollution-control plans intended to impact area-wide water problems such as erosion and sedimentation. These plans universally endorse the "best management practice" of retention and enhancement of vegetation, especially along streams, to diminish bank erosion and filter overland runoff before it reaches water bodies. However, regulatory standards have not evolved from these plans.

b. Fish and Wildlife Coordination Act (16 USC Sec 661 et seq.). This act provides for consultation by Federal agencies with the Service, as well as the state's wildlife agency, when "waters of any stream or other body of water are proposed to be controlled or modified." The USFWS also advises the Corps in its regulatory role. Resources are to be conserved to the degree possible, consistent with the primary purposes of the project.

c. Endangered Species Act (16 USC 1531 et seq.). The section of primary interest in this act allows the Service to define critical habitat areas for endangered species. Threats to these areas can thereafter be addressed by acquisition, development reviews, or establishment of mitigation and enhancement measures. However, it should be noted that habitat does not necessarily have to be defined as critical to be considered important by the USFWS.

d. Small Watershed Protection and Flood Prevention Act (PL84-566; 16 USC 1002). Often referred to as the act for PL566 projects, it authorizes the Secretary of Agriculture to direct the Soil Conservation Service (SCS) to conduct soil conservation and flood-control projects in areas not exceeding 250,000 acres and for reservoirs storing not more than 25,000 acre-feet of water. Current funding arrangements have resulted in Federal monies being used to fund stream channelization, while financing only half of the fish and wildlife mitigation measures. PL566 projects have almost uniformly resulted in destruction of riparian systems (Jones, 1982).

e. Federal Flood Disaster Prevention Act (PL93-234). This act established the Federal Flood Insurance Program, which has provided some incentives for construction outside flood-prone areas. To a limited degree, this has reduced destruction of riparian vegetation by developments. President Carter issued two executive orders in a related effort: EO11988 directed Federal agencies to avoid construction in flood-hazard areas and to seek restoration and preservation of the natural and beneficial values of floodplains; EO11990 directed Federal agencies to minimize the destruction, loss, or degradation of wetlands.

f. National Environmental Policy Act (42 USC 4321 et seq.). This act sets general goals of environmental protection for Federal agencies and requires preparation of Environmental Impact Reports (EIRs) for many federally financed projects. Like the California Environmental Quality Act (CEQA), it is frequently treated in a perfunctory fashion (Jones, 1982), but has potential for flood-plain management (Williams, 1979).

6.2.2 Federal Programs and Agencies

a. Army Corps of Engineers. The Corps is responsible for a broad mix of programs, including regulation (Section 404 permits under the Clean Water Act) and construction of water, flood, and navigation projects. The Corps was given nationwide responsibility for flood works by the Flood Control Act of 1936, and these projects generally result in substantial removal of riparian vegetation.

b. Farmers Home Administration. The Farmers Home Administration in the Department of Agriculture, is a rural credit service agency for farmers, rural residents, and small communities. Loans can be for improvements on farm lands and forests, including development of drainage and other soil and water conservation facilities. There are no firm conditions on these loans to ensure that they are not used to remove riparian vegetation.

c. Soil Conservation Service. The SCS in the Department of Agriculture, provides a broad range of services from soil conservation to flood control, working with farmers through the States' Resource Conservation Districts. Projects funded under the Small Watershed Act (PL 84-566) usually involve stream channelization and riparian vegetation removal. In addition, Section 216 of the Flood Control Act of 1950 allows the SCS to provide emergency actions to control runoff and reduce erosion. The Office of Coastal Zone Management prepared a paper on the role of the conservation districts in the Coastal Zone Management Program (NACD, 1980).

d. U.S. Fish and Wildlife Service. The USFWS, in the Department of the Interior, is the Federal agency responsible for planning and management of many of the nation's fish and wildlife resources (anadromous fish are the concern of both the USFWS and the National Marine Fisheries Service). The USFWS implements the Fish and Wildlife Coordination Act (16 USC 661, et seq.) and Endangered Species Act (16 USC 668, et seq.). It also acquires habitat areas under the Migratory Bird Conservation Act (16 USC 715 et seq.) and the Land and Water Conservation Fund Act (PL 88-578; 16 USC 4601 et seq.). The USFWS has been the most active of all Federal and State agencies in promoting protection of riparian systems (Jones, 1982). One of its products with the SCS is "Channel Modification Guidelines," (Federal Register, March 1, 1978), which includes the following:

> It is the policy of the SCS and the USFWS that care and effort will be made to maintain and restore streams, wetlands, and riparian vegetation as functioning parts of a viable ecosystem upon which fish and wildlife resources depend.

e. U.S. Forest Service. The USFS, in the Department of Agriculture, manages 20 million acres of land in California. As early as 1975 the California region of the USFS issued a booklet entitled "Management of Riparian Habitats," which offered objectives to "preserve the productivity of riparian habitats through maintenance of vegetative stratification and integrity." Nationally, the USFS Manual, Section 2526 (1980), includes an objective of recognizing the "unique values of riparian areas and emphasize the protection, management, and improvement of them during the planning and implementation of land and resource management activities." USFS Region 5 (including California) has a policy seeking buffer strips for streams, recognizing riparian habitat as "one of the most productive areas for flora and fauna in the forest environment," and calling for "minimum disturbance from management activities."

6.3 STATE OF CALIFORNIA

6.3.1 California Laws

California laws with the most significant effects on riparian resources are listed below.

a. Doctrine of the Public Trust. This doctrine, derived from English common law, provides an important philosophical, historic, and legal base for governmental regulations to protect tidal and submerged lands and navigable waterways. The Public Trust Doctrine does not affect riparian vegetation directly, but has been relied upon to justify the reservation of instream flows necessary to support fish, wildlife, and habitat.

b. Land use.

1. Act (Public Resources Code Sections 21000 et seq.). The CEQA provides a mandate to protect California's environmental quality but is too often circumvented (Jones, 1982), as shown in Figure 53.

2. Resource Conservation Act (Public Resources Code Section 9001 et seq.). This law provides for a good state-local

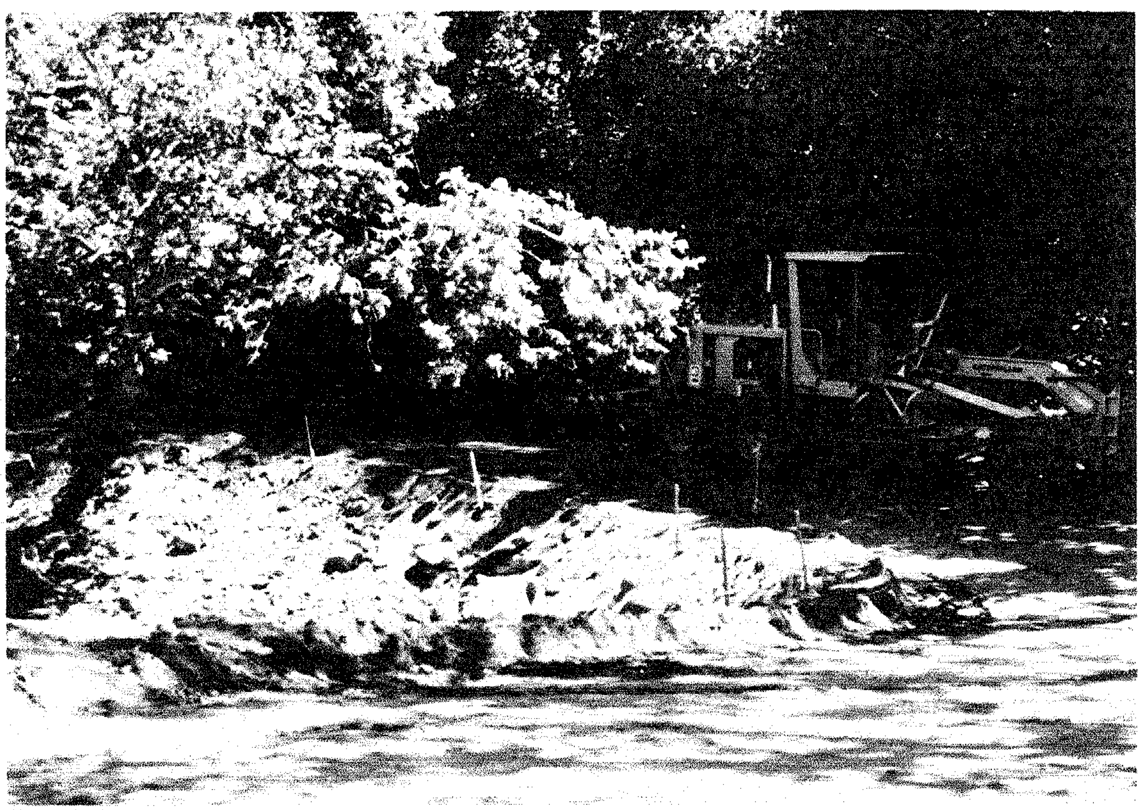


Figure 53. Public works projects carried out in the riparian corridor are frequently exempt from the CEQA process, as shown here in a project on a tributary to the Santa Margarita River in San Diego County. Photograph by Anne Sands.

cooperative process that could greatly advance the use of "best management practices" for soils and streams management. Inadequate funding of the State Resource Conservation Commission and the Division of Soils Conservation, Department of Conservation has left resource conservation districts to their own initiatives. In fact, these districts work more closely with the SCS than with the State of California (Jones, 1982).

3. Surface Mining and Reclamation Act (PRC2710 et seq.). This act requires the State Mining and Geology Board to adopt State policy for the reclamation of mined lands. Buffers and protection of water resources and riparian vegetation are required.

c. Water management.

1. California Water Code, Sections 1243. This section declares the reservation of water for the enhancement and protection of fish and wildlife to be a beneficial use.

2. Davis-Dolwig Act (Water Code, Sections 11900-11925). This act funds the mitigation of adverse impacts from water project development and requires direct planning efforts to protect resources as part of project design. The act sets forth explicit State policies requiring projects to avoid or minimize impacts on waterways.

3. Porter-Cologne Water Quality Control Act. This is the State's primary water law, it gives the State Water Resources Control Board (SWRCB) and the nine regional water quality control boards substantial authority to regulate water use. In 1983 the SWRCB established standards for retention of instream reservation of waters. This effort promises to be one of the State's most important programs to protect the integrity of waterways, wetlands, and adjacent riparian vegetation.

d. River and stream management.

1. California Water Code, Section 8125-8127. This is the authority for counties to improve (that is, alter for flood-control purposes) non-navigable streams. It is not matched with clear State policy or mandates to preserve the environmental features of these streams or to avoid or minimize the placement of fill in them. These sections could be amended to establish a State policy supporting conservation of streams (Jones, 1982).

2. Stream Alteration Controls (Water Code, Sections 5653, 1505, 1601-1606). The Department of Fish and Game's authority over the use of suction dredges (Fish and Game Code, Section 5653), alterations of fish spawning areas (Fish and Game Code, Section 1505), and alterations of stream beds in general (Fish and Game Code, Sections 1601-1606) are all useful tools for the protection of instream resources (but generally not for riparian vegetation outside of the stream or overflow areas). The 1601-1603 agreements (1601 covers public projects, while 1603 addresses private work) do not have the status of State approvals under law, instead providing for a negotiation and agreement process.

e. Floodplain management. The State has substantial legislative vehicles for constructing flood-control facilities, but little statewide authority to establish regulations limiting development in floodways and flood-risk areas, called "non-structural floodplain management." A comprehensive State floodplain management act could provide an effective umbrella for protecting all water-related resources--streams, wetlands, overflow areas, and riparian vegetation--as well as upgrading the protection of public health and safety.

f. Coastal zone management. The Coastal Act (Public Resources Code, Section 30000 et seq.). The most effective wetland and stream protection policies in any Federal or State law are found in the Coastal Act of 1976, especially Section 30231 as follows:

> The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, enhanced through, among other means, minimizing adverse effects of waste

water discharges and entrainment, controlling runoff, preventing depletion of ground-water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.

Policies such as the above have been administered through the Coastal Commission's permit authority. Certification of local coastal programs transfers resource protection into local government processes.

Of special interest is the Coastal Commission's document, Interpretive Guidelines for Wetlands and Other Wet Environmentally Sensitive Habitat Areas (adopted February 5, 1981). These guidelines have improved management of coastal resources, and particularly the maintenance of "environmentally sensitive habitat areas." Regarding development near these areas, the guidelines rely on the use of hundred-foot nondevelopment buffer zones. No attention is given to criteria for the design and siting of adjacent construction to minimize adverse impacts (Jones, 1982). The Commission has attempted to provide an example for other jurisdictions in preserving riparian habitat on the south-central coast; however, the area of jurisdiction is narrow and the outlook uncertain as local governments take over authority (Zentner, 1981; Capelli and Starkey, 1984).

g. Wildlife Habitat Conservation. The State has substantial declarations of policy regarding the preservation of rare and endangered species and the wise management of all living resources. However, there is little legal or regulatory process--except in the Coastal Act--to reduce and mitigate impacts on wildlife habitat (much of which is water-related). California, for example, lacks the Federal Endangered Species Act requirements that public investments and actions be withheld where they would damage critical habitats of threatened species (Jones, 1982).

6.3.2 State Regulations and Agencies

a. Department of Fish and Game. Much of the work of Department of Fish and Game is oriented toward saving wetland, aquatic, and riparian habitat, but the agency has few tools to do so. Of special interest is the Department of Fish and Game authority in Sections 1601-1606 of the Fish and Game Code to execute stream-bed alteration agreements for any activity that will divert, obstruct, or change the natural flow or bed of a river, stream, or lake. This is an important negotiation and mediation process, but it suffers from personnel shortages and lack of public awareness (Jones, 1982). Long-term preservation of riparian habitat would be advanced if Department of Fish and Game were to initiate programs to solicit land donations of riparian corridors and to restore riparian habitat on public lands.

b. Department of Water Resources. Under the previous administration, Department of Water Resources increased its policy support for preservation of riparian vegetation and instream retention of water (see Policies and Goals for California Water Management for the Next 20 Years, public review draft of Bulletin 4, September 1981). Under the current administration, policies protecting riparian vegetation have been given low priority (Jones, 1982). In 1982 Department of Water Resources began an Urban Streams Cleanup and Restoration Program that included vegetation planting and restoration. The program was refunded in October 1984.

c. State Coastal Conservancy. This agency works with local agencies, landowners, and nonprofit organizations to enhance, restore, and protect coastal resources. Since 1978 it has been funding coastal restoration and enhancement projects, including several wetlands in Southern California. In recent years a new emphasis has been placed on watershed management and the restoration of streams and riparian zones; however, the agency's wetland program does not require co-sponsoring local jurisdictions to offer guarantees that they will establish adequate erosion controls (including the use of riparian vegetation zones) in the the watershed to minimize sedimentation that could erase public investments in wetlands by a severe winter storm (Jones, 1982).

d. Department of Parks and Recreation. This agency is responsible for the purchase and management of lands suitable for public recreation. Department of Parks and Recreation can classify wetlands, streams, and riparian forests within the park system as natural preserves, which prohibits development of these areas for parking lots, camping grounds, and other intensive uses. According to the department, the designation has not been used extensively (Jones, 1982).

e. Department of Conservation. The department is concerned largely with regulating mining and gas/oil operations, but also has a limited soil-conservation program. Its Division of Mines & Geology regulates gravel and sand mining. A conditional use permit is required, as is a reclamation plan under the Surface Mining and Reclamation Act of 1975. The status of riparian systems and river restoration is supposed to be monitored annually in mining areas. In its useful but never officially released publication, California Soils: An Assessment (1979), the department ranked streambed erosion as the third most severe of California's 11 soil problems. Retention of riparian vegetation as a protective measure was not stressed in this document. The otherwise excellent Erosion and Sediment Control Handbook (1978) suggests only that "vegetative lining reduces the erosion along the channels and provides for the filtration of sediment... and improves wildlife habitat." In Southern California each county has a Department of Conservation-approved ordinance regulating sand and gravel operations.

f. Department of Health Services. Concerns of this department illustrate the competing interests that must be considered in water-related resources management. For instance, thickets of streamside growth, especially blackberry tangles in urban areas, can harbor rats and are, therefore, discouraged by the department.

g. Wildlife Conservation Board. The Wildlife Conservation Board has an active wetland and riparian forest acquisition program that can include restoration of such areas. Within the study area, for example, the Wildlife Conservation Board has purchased the Hidden Valley Wildlife Area on the Santa Ana River (1,267 acres).

6.4 LOCAL GOVERNMENT

6.4.1 Local Government Plans

There is great variation among jurisdictions in the plans and ordinances used for resource management. In most cases there are no state standards for consistency, adequacy, or effectiveness of local plans and ordinances. Tools available to local governments for resource management are listed in Table 13. This is followed by a description of some of these tools.

a. General plans. The local government general plan, as defined in Government Code, Sections 65300 through 65403, is a vehicle for the collection and presentation of local and State policies (including goals, objectives, and sometimes recommendations) regarding the future development of the area. The text of the general plan is essentially a nonbinding statement of intent. However, the land-use maps that are part of the general plan (usually the land use and circulation elements) must be compatible with the zoning designations, as mandated by the legislature in 1971 in Government Code, Section 65860. Policies in local plans can be presented as a call for action or as a recommendation for future consideration, which is often a misleading substitute for commitment (Jones, 1982).

b. Area plans. These are mini-general plans developed for a specific region or portion of the jurisdiction. They have the advantage of allowing a jurisdiction with many types of terrain or varying development pressures to address land-use concerns more thoroughly. Their effectiveness, however, still depends on the specificity and integrity of the implementing ordinances.

c. Stream conservation plans. Local government interest in streams has been limited largely to flood-control projects. Conservation plans and programs for waterways have not been common.

Table 13. Local tools for resource management.

1. Plans
   - General plan (including land use/circulation elements; open space/conservation elements; recreation/scenic highway elements; and safety elements).
   - Area plan
   - Stream conservation plans
   - Significant resource area inventories
2. Ordinances
   - Zoning ordinances
   - Local ordinances
   - Use permits
   - Open space, conservation, or resource management districts
   - Overlay or combining districts
   - Watercourse or streamside protection ordinances
   - Floodplain management ordinances
   - Setback requirements
   - Grading ordinance
   - Erosion control ordinances
   - Surface mining and reclamation ordinances
   - Design control district ordinance
3. Integrated Plans and Ordinances
   - Planned unit developments
   - Specific plans
   - Special planning area ordinances
   - Subdivision ordinances
   - Local coastal programs

d. Significant resource area-inventories. The identification of "significant" resource areas, with policies for their protection, can be incorporated into the conservation/open space element of the general plan or placed in a separate document. For example, Los Angeles County has incorporated an inventory of 65 significant ecological areas in its conservation/open space element (1979), including streams, riparian vegetation areas, and marshes. The use of zoning or some variation of the police power is, of course, the vital element. Lists of such areas accomplish protection only when they are connected with California Environmental Quality Act (CEQA) and regulatory processes.

6.4.2 Ordinances

a. The zoning ordinance. The zoning ordinance is one expression of the police powers available to local governments to regulate land use. Typically the zoning districts include blocks of land for residential, commercial, industrial, agricultural, and, since the 1970s, some open-space uses. There are variations and subgroups with each category (such as residential/single-dwelling and residential/multiple-dwelling). Designations and names of zoning districts vary among jurisdictions. While most open-space districts do not include specific comprehensive standards for all forms of uses and impacts, there is no reason why they cannot.

b. Local ordinances. Other ordinances can be used to manage or protect resources, especially when a uniform rule of conduct is needed for consistent application across all land use zones (such as for the protection of stream resources).

c. The use permit. Local governments have numerous types of permits for the many uses they must regulate. A use permit is simply a regulatory tool that, when backed up with an explicit ordinance, allows the jurisdiction to authorize developments or uses subject to conditions that protect public health, safety, and welfare. The use permit is an important part of ordinances that regulate uses in sensitive environmental areas.

d. Open-space, conservation, and resource management districts. Open-space districts go by many names, including conservation, resource management, and even agricultural. Though these districts usually address only broad land-use requirements, they can be made to include specific requirements such as protection of stream zones.

e. Overlay or combining districts. An overlay or combining district is an additional zoning designation placed on top of the existing zoning, usually for an area having special problems or needs. Uses in this area must conform to all the standards of both designations. This may be the best local tool for protecting significant resource areas. For example, in Santa Barbara County Local Coastal Programs (1979) its process is described as follows:

> The land-use plan proposes an Environmentally Sensitive Habitat Area overlay designation to address the deficiencies in existing regulatory procedures. The overlay designation symbolically indicates the locations of most habitat areas on the land-use maps.

Such an ordinance is an effective tool, if properly implemented, for management of sensitive resource areas.

f. Waterways conservation ordinance. This form of ordinance is the most effective of all approaches for riparian system protection. An ordinance of this type can call for the preservation, protection, and restoration of riparian corridors in order to: protect wildlife habitat; protect water quality; protect aquatic habitat; protect open-space; promote cultural, historical, archeological, paleontological, and aesthetic values; transport and store flood waters; prevent erosion; and generally promote public health, safety, and welfare.

Among California counties, zones of protection of streams and their resources range from 25 to 150 ft, sometimes varying in width under different conditions. In such a zone a permit is required for alterations as specified in the ordinance. At least one jurisdiction requires denial of the project when the work would "destroy a significant amount of riparian cover." No jurisdictions in Southern California have made use of this type of ordinance (Jones, 1982).

g. Floodplain ordinances. One of the most important kinds of ordinances can be that for flood-plain management. Not only can a good ordinance protect public safety by limiting development in hazardous areas, but it can also reduce public expenditures for relief from flood damages and retain agricultural uses in these areas. Broadly defined, a flood plain includes almost all water-related resources except for isolated springs, vernal pools, and freshwater marshes with water sources other than streams. Therefore, a comprehensive local floodplain ordinance can be the major vehicle to manage alterations of floodways, wetlands, streams, and riparian vegetation. Few California ordinances are comprehensive and most are quite conservative (Jones, 1982).

6.4.3 Southern California Jurisdictional Plans

a. Santa Barbara County. The Santa Barbara County Local Coastal Plan, mandated by the Coastal Act of 1976, includes numerous flood-plain, wetland and waterways policies and establishes a Sensitive Habitat Area overlay. The document requires that all development in designated flood-hazard areas and within 50 ft of any stream or river in the area between Ellwood and the Santa Maria River shall be reviewed by County Flood Control for conformance with policies for flood-proofing and protection of the floodway. Riparian vegetation is not specifically mentioned. Policies in the conservation element of the plan are advisory rather than mandatory; consequently, protection of habitat is frequently left to the environmental review process under CEQA.

b. Ventura County. Ventura County's protection of riparian systems is limited primarily to management of sand and gravel mining on the Santa Clara and the Ventura Rivers. A sample permit for mining requires that a new diversion channel be built around the excavation area and that a minimum 60 ft-wide buffer zone on both sides of the channel be "maintained free of all excavation and other operations to protect riparian vegetation and control sediment."

In the county's Local Coastal Program, Environmentally Sensitive Habitat Areas are designated for use in the coastal zone. Included in the LCP discussion is the importance of protecting riparian vegetation along creek corridors, but there are no specific policies or ordinances to implement that goal.

c. Los Angeles County. The Conservation/Open Space Element for Los Angeles County (adopted as part of the general plan revision of 1979) includes language that states the need "to protect...watershed, streams, and riparian vegetation to minimize water pollution, soil erosion, and sedimentation, maintain natural habitats, and to aid in ground water recharge." There are 65 identified significant ecological areas in this element that are listed in a report entitled "Land Capability/Suitability Study, Los Angeles County General Plan Revision Program" (1976). Streams, riparian vegetation areas, and marshes are included in this listing, but are protected primarily through the CEQA environmental review process (local permits can be conditioned to protect them but are not required to be so written).

The county's Flood Protection District requires that structures be kept away from stream courses to prevent bank erosion.

d. Orange County. The Orange County General Plan Land Use Element (March 1975) contains general policy language to restrict development in designated flood plains and on or adjacent to rivers, creeks, streams, and other riparian areas. Additional policies support the concept of maintaining stream courses, estuaries, and other water bodies in their natural state, consistent with public safety.

The Open Space Element (June 1973) seeks to preserve "the natural resources of the county, plant and animal life, fish and wildlife habitat, study areas, rivers and streams and their banks, bays and estuaries, and watershed lands."

The Conservation Element (January 1978) is more detailed in its recommendations and text but again is not backed up by implementing ordinances. The Local Coastal Plan has not yet been completed by Orange County or certified by the Coastal Commission (November 1985).

e. Riverside County. As part of the Riverside General Plan, an open-space and conservation plan has been developed to preserve, protect, and manage resource areas identified in the Open Space and Conservation Inventory. This is accomplished through resource maps and programs throughout the Environmental Hazards and Resources Element of the general plan. A vegetation resources map identifies riparian areas. It is the policy of the county to maintain and update these inventories, but review of all development proposals in identified riparian areas is accomplished only through the CEQA process.

Critical habitats are delineated on the Vegetation Resources Map as either water resources/flooding areas or wildlife/vegetation areas. Both are restricted to open-space and limited recreational uses; research and educational uses are additionally permitted in wildlife/vegetation areas. The county's open space zoning designations further carry out the objectives and policies of the Open Space and Conservation Plan.

f. San Diego County. The following policies are set forth in the Conservation Element (May 1983) of San Diego's General Plan:

> Flood control measures shall, whenever practical, utilize natural floodways and floodplains, maintaining riparian habitats and historic stream flow volumes. No structures or excavations which adversely affect flood-plain vegetation and wildlife, or decrease their value as migration corridors should be permitted.
>
> Storm drain runoff should be planned and managed to...enhance wildlife, and reduce the impact of erosion.

> The county will act to conserve and enhance vegetation, wildlife, and fisheries resources.

The element also calls for the use of mitigating measures for projects with unavoidable adverse impacts on habitat. It recognizes the Resource Conservation Area (RCA) overlay designation, as defined in its Land Use Element, which is applied to several areas with riparian woodland.

In the county's open-space element (August 1977) are objectives seeking conservation of the habitats of rare or endangered plants and wildlife, plus the "use of streams as local open spaces." The element calls for the development of "comprehensive plans for the floodplains" of all major rivers under the County's control. One such plan, prepared for the San Dieguito River (March 1982), states that:

> maintaining the floodplain in an open condition provides the opportunity for an environmental system involving a riparian and floodplain ecosystem... and live stream. A natural riparian system...will maintain the scenic quality of the river area.

These goals would be accomplished by prohibiting development in the floodway and encouraging clustering of houses outside the boundaries of the floodplain. There is no specific prohibition against removing riparian vegetation or encouragement of its enhancement.

The county's Local Coastal Program includes the San Dieguito Land Use Plan (July 1982). In a section on environmentally sensitive habitats is a prohibition of "any development or other significant disruption" of riparian habitat in the study area. The LCP also includes a zoning ordinance (March 21, 1984) that establishes an Ecological Resource Area that is designed primarily to protect wetlands but is also applied to "lagoons and their tributary streams and adjacent uplands within the California Coastal Zone." Removal of riparian vegetation is not specifically prohibited or regulated, although development standards are intended to "conserve the widest variety of physical and vegetation conditions to maintain habitat diversity."

6.5 SUMMARY

There are numerous Federal and State laws and agencies, as well as local ordinances and districts, that have regulatory functions affecting riparian zones. Many of the laws and regulations conflict or overlap. Some protect resources; others permit resource consumption or degradation. The best protections are offered by the Coastal Act of 1976; however, the boundaries of the coastal zone are narrow and do not extend upstream or consider watersheds (see Figure 1 in Chapter 1, which depicts the project study area). A comprehensive management program with a clear enumeration of resource priorities that apply to overlapping jurisdictions would provide greater riparian protection and restoration potential.

CHAPTER 7. RIPARIAN ECOSYSTEM RESTORATION

7.1 INTRODUCTION

Since the mid-1960s there has been increasing interest in protecting riparian habitat, both on a national level and in California (Jahn, 1978). The USFWS and the California Department of Fish and Game, both charged with wildlife management, have developed policies and goals relating to protection of riparian areas. A number of environmental groups, including the National Audubon Society, the Sierra Club, and The Nature Conservancy, have made the protection and restoration of riparian habitat a high priority. They view riparian areas as important upland extensions of marshes and wetlands. By protecting creeks, reducing erosion, and preserving or reestablishing riparian vegetation, they feel it is possible to improve the health of downstream marshes (Nunnally, 1978).

Nevertheless, the primary social trend in Southern California is still toward development of the flood plains, which almost always involves elimination of riparian corridors of vegetation (Warner, 1983). New requirements for restoration of degraded riparian habitat have been viewed as a nuisance by some developers, since restoration and mitigation plans cost money to implement and can add time to project schedules. In addition, riparian corridors are considered overgrown jungles rather than a feature that enhances property values. Examples of riparian habitat are listed in Appendix D.

7.2 LAND USE AND OWNERSHIP PATTERNS

One of the difficulties in carrying out significant stream restoration projects in southern coastal areas results from the need to gain the cooperation of numerous landowners and local government jurisdictions. In Northern California, there might be three large ranch properties located in one or two counties. In Southern California, however, land ownership along a river usually includes many small parcels with frequent changes in ownership. In addition, there are many incorporated areas, and counties frequently manage small parcels between incorporated cities. Projects become complex and require time-consuming coordination efforts.

Rivers and streams in Southern California, some draining sizable watersheds, also are divided into numerous ownerships, and thus are not easily incorporated into a regional watershed management plan. In general, the more complicated the ownership along a river, the greater the chances for failure in reaching a management consensus among all landowners. If any owner chooses not to participate, the overall success of the restoration program is diminished. Depending on the size of the parcel in question, any omission has the potential to reduce the effectiveness of a watershed management or riparian restoration plan.

7.3 CONFLICTING OBJECTIVES

Protecting and restoring riparian areas often is in direct conflict with traditional floodplain management (Detwiler, 1980; Goldner, 1981; Jordan, 1984). Since high priority is given to protection of public property, the majority of rivers in Southern California, in both urban and agricultural areas, have structural flood-control devices, dams, and concrete channels. Little or no attention has been given to maintaining natural meanders, to hydraulic processes in streams, to wildlife needs, or to impacts on downstream wetlands (Kibby, 1978). Many activities permitted in flood plains, such as public parks, golf courses, and agriculture, eliminate or drastically reduce riparian habitat and are very damaging to riparian wildlife.

Because of the lack of baseline data on restored riparian areas, uniform guidelines for successful restoration projects have not been developed (Dawson, 1981). Each permit application involving restoration work is conditioned independently. Conditions on permits vary considerably, depending on the qualifications of staff and available time for review. Consultants preparing EIRs must propose mitigation measures for impacts on riparian areas in the absence of accepted criteria for measuring these impacts. As a result, restoration plans tend to be based on estimates of potential impacts of a project and restoration work that may be needed rather than on long-range habitat enhancement objectives (Prunuske and Morrison, 1982). The criteria for design of a revegetation plan should be agreed upon before the project is designed. Without this early agreement among the parties involved, it is highly probable that a restoration program will fail.

Wildlife-management agencies will sometimes agree on overall goals of habitat restoration, but will fail to agree upon specific plans because of their focus on an individual species. Should vegetation be managed for red-shouldered hawk habitat and other raptors that require a mature overstory, or for the rare and endangered least Bell's vireo and willow flycatcher that require young willow thickets (Fitch et al., 1946; Zembal, 1984b)? Determinations of management objectives must rely on subjective judgments since vireo, flycatcher, and raptors are all in need of habitat protection. Better interagency coordination could help in resolving management conflicts, but there will always be differences of opinion over which species "deserves" more protection.

Negotiation is a critical step in determining revegetation plan requirements. If this process is unsatisfactory for any of the parties involved, the solution is likely to be a political one and the entire program may suffer (Fisher and Ury, 1984).

7.4 TIMING CONFLICTS IN RESTORATION PROJECTS

A number of permitting procedures create confusion and conflicts for those implementing a restoration project. Most procedures do not provide for advance planning in ordering plants from nurseries. For example, the CALTRANS (California Department of Transportation) staff may not know what mitigation will be required by the USFWS and the Department of Fish and Game until just before construction begins. There is often too little time to ensure an adequate supply of a desired species from the nursery.

The timing of construction may create another kind of difficulty in that construction may be limited to late summer because of bird migration or nesting events. If construction is completed in fall, plantings may not be well enough established to survive winter rains; if planting is postponed until winter or spring, rains may cause extensive spoil erosion. In addition, early spring plantings may interfere with early spring nesting.

The third type of conflict occurs when a time limit is set on agency funding. For example, when CALTRANS funds a mitigation project as part of a bridge construction project, the mitigation is considered to be part of the project cost. CALTRANS, however, considers any activities after the 2-year construction period to be maintenance, and that agency does not pay for maintenance. If a riparian revegetation program has not been implemented before the 2-year period has elapsed, CALTRANS considers itself no longer responsible for funding the program (J. Rieger, CALTRANS, Sacramento; pers. comm., 1984).

7.5 ENFORCEMENT OF MITIGATION

A major constraint in achieving restoration of riparian habitat is the lack of regulatory mechanisms to enforce mitigation conditions. In a number of cases in the Southern California study area, permits for construction projects have been issued and a bridge or facility has been built, but no revegetation has been attempted (Wheeler and Fancher, 1981). Although considerable time may have been devoted to working out conditions to mitigate project impacts, nothing was done to enforce these conditions and the mitigation never took place.

Funds are not generally available to city, county, State, or Federal agencies to conduct a monitoring program for riparian habitats. These agencies usually do not have the inhouse expertise needed to monitor and interpret results observed during revegetation projects. When inspections do occur, the inspectors often do not have the training to determine whether the vegetation specifications are being followed or to understand what the specifications mean and how critical they can be. For example, in one case, time requirements for revegetation were waived so that when the vegetation was finally installed at the wrong time of year the plants did not survive (J. Rieger, pers. comm.). There is no formal process or enforcement power to ensure that permit conditions are complied with or are carried out in a way that ensures success.

In addition to lack of enforcement and follow-up of revegetation conditions, local grading ordinances often contain weak language such as "where feasible." Riparian corridors often are severely damaged during clearing and grading operations by bulldozer operators who are not given specific guidelines to follow when working near creeks. Slopes may be properly or improperly formed, and erosion from winter rains may create gullies and carry off valuable soil (Gray and Leiser, 1982). Because of these limitations, the enthusiasm of field staff of local, State, and Federal agencies for protecting wildlife habitat too often wanes due to lack of enforcement and followup at the administrative level.

7.6 RESTORATION POTENTIAL IN SOUTHERN CALIFORNIA

Many rivers and streams in Southern California still support large stands of riparian vegetation, although some are severely degraded, particularly the understory. Other rivers have little remaining vegetation but have not been extensively channelized. Where sufficient water flows for some portion of the year, and the river has not been channelized, there is a potential for restoration of riparian habitat. Where water tables have been lowered by gravel mining and the natural stream contours severely altered, the potential for restoration is reduced.

The following sections discuss a basic approach to riparian habitat restoration, much of which is derived from the experience of those involved in a summary of restoration projects carried out in Southern California and listed in Appendix E.

7.6.1 <u>Development of Restoration Plans</u>

At the outset of a restoration project, the following questions need to be answered:

- Who are the interested parties and what roles will each play?
- Who will pay? Who will benefit?
- What public agencies and interest groups will be involved?
- What are the restoration goals?
- What work needs to be done?
- Who will take the lead in design and implementation?
- Who will manage and maintain the site and for how long?
- Who will monitor and how often?
- What activities will be allowed or restricted?

The size of the project and the number of interested parties will influence the complexity of the answers to these questions. An advisory committee to oversee the project, to establish goals, and to keep energies focused on the desired outcome may be helpful to all parties concerned (EPA, 1972; Detwiler, 1980; Herbkersman, 1982).

7.6.2 <u>Establishing Goals</u>

Often, the primary goal of a restoration plan is to mitigate the effects of unavoidable habitat losses by creating or restoring habitat elsewhere, either on or off the project site. There are sometimes limitations to this traditional approach to mitigation, since mitigation does not necessarily increase wildlife management options; in fact, it usually entails management of remaining habitats to increase or improve wildlife use. Each development project makes another long-term withdrawal from the regional supply of wildlife habitat, so mitigation activities must address a continually shrinking supply (Farmer, 1979; Schiechtl, 1980). This limitation of the traditional mitigation concept can be overcome by requiring replacement of habitat lost on at least a unit-for-unit basis.

According to Short and Schamberger (1979), three considerations must be met in order to achieve effective mitigation: (1) fish and wildlife needs must be addressed early in the planning process; (2) quantitative methods must be used to predict and evaluate impacts and to measure the effectiveness of mitigations; and (3) mitigation measures must be initiated and monitored during project implementation.

Restoration goals may include:

- creation of habitat for endangered plants and animals;

- use of plant communities to improve water quality;

- creation of vegetated corridors to facilitate movements of animals between isolated woodlands;

- planting of vegetation to reduce bank erosion;

- development of recreational opportunities for the local community.

Goals for each project should be written into the revegetation plan and should be referred to frequently to be sure that implementation of the plan is meeting the goals established.

7.6.3 Critical Elements in a Restoration Design

a. Flow regime. Riparian vegetation and river channels can change significantly in 1 or 2 years in response to events such as drought or flood. Therefore, a revegetation plan must be based on the most recent data available for the site, including measurements of channel and bank elevations. All decisions about grading, selection of plants, irrigation, and maintenance should reflect land and water elevations at the site. Upstream diversions and historic flow records, including 50- and 100-year storm data, must be taken into account in the design of channels and planting plans. If this information is not considered, the goals of revegetation are not likely to be met. In one case study, a pier was improperly constructed so that ponds began filling with sediment. What had been intended as an open-water area with wooded islands for nesting birds became a cattail marsh (Appendix E, Example 12).

An examination of the river and its vegetation of locations experiencing the predicted project flows should enable the planner to select appropriate plants for the revegetation plan. Of course, if vegetation already exists at the project site, efforts should be made to retain it as part of the final project design as long as it is likely to survive under any altered flow conditions.

b. Understory. The understory is an important consideration in designing a riparian vegetation restoration plan. According to H. Wier (Wier Biological, San Diego; pers. comm.), in natural and undisturbed riparian forests along the Santa Margarita River, about 80 percent of the vegetation is composed of about 45 understory species growing below cottonwoods and willows. Wier says that one of the biggest problems with revegetation and restoration plans is that the plan promises the world but delivers only willows and cottonwoods. The tendency is to forget an understory was ever there, and thus understory plants are omitted from revegetation plans. When these plants are included, they often die from improper handling and lack of protection.

Understory vegetation is an important source of food and cover for wildlife. It also holds soil moisture and provides some erosion control. Planting for maximum habitat diversity means including a variety of appropriate understory plants. In disturbed areas, the understory may be difficult to re-establish because of the dominance of non-native introduced plants, specifically tamarisk (Tamarix spp.), cane plant (Arundo donax), and castor bean (Ricinus communis). Nevertheless, it is feasible to remove the undesirable plants and revegetate with native understory species.

c. Buffers. Buffers are an essential part of many riparian restoration plans, but few planners agree on how wide a buffer should be or on what activities are acceptable in a buffer zone. More needs to be known about what actually happens to riparian vegetation with and without buffer areas. At present, it is generally assumed that buffers are necessary, yet requirements vary from project to project.

Buffers, which include native plants, should be designed to provide some habitat values as well as aesthetic values. They should serve as a transition zone between the orderly urban landscape and the naturally random riparian forest.

Features allowed in the buffer area could include bike paths, pedestrian walkways, and other passive recreational facilities. Motorized vehicles should be prohibited, except as necessary for safety or maintenance. Criteria for establishing the size of buffer areas will depend on such standards as:

- biological significance of the adjacent riparian lands;
- sensitivity of wildlife to disturbance,
- susceptibility of riparian area to erosion from landward development;
- use of natural topographic features to buffer development;
- use of existing man-made features (roads, levees, etc.) to locate buffer zones;
- type and scale of development proposed.

The appropriate buffer width will vary according to the standards mentioned above, but a minimum of 100 ft is desirable.

d. Corridors. There is a need to link riparian wildlife corridors whenever feasible, rather than to allow continued isolation of small riparian groves. In designing a revegetation plan, it is important to maintain or re-establish continuity with adjacent habitats. This means allowing "fingers" of chaparral vegetation to extend down into the riparian zone. This allows movement of upland wildlife into the riparian corridor and provides additional foraging habitat for riparian wildlife species.

Likewise, there is a need to re-establish connections between riparian groves separated by development. This can be accomplished by replanting narrow bands of vegetation to link the disjunct groves. Riparian corridors are logical candidates for greenbelt and open-space designation and can add aesthetic qualities as well as biological values to the property (Salata, 1983). Any existing and potential wildlife habitat on the site should be considered for incorporation into the revegetation plan. Flood retention basins are candidates for revegetation and can greatly enhance the property's value for wildlife. Suitable vegetation can be planted in a corridor connecting a pond or basin with a riparian revegetation area, increasing overall wildlife use by providing a protected travel route between the two habitat types.

7.6.4 Implementation

As a general rule, a vegetation plan should be implemented during or immediately after project construction (Figure 54). Restoration should be performed in stages, each with a specific date of completion. This allows careful monitoring of progress and assures that a planting schedule will be followed. Whenever possible, construction should be done before or after critical nesting and rearing periods for onsite wildlife to avoid unnecessary impacts. If vegetation must be removed, this should be accomplished well before the nesting season. If a long section of river

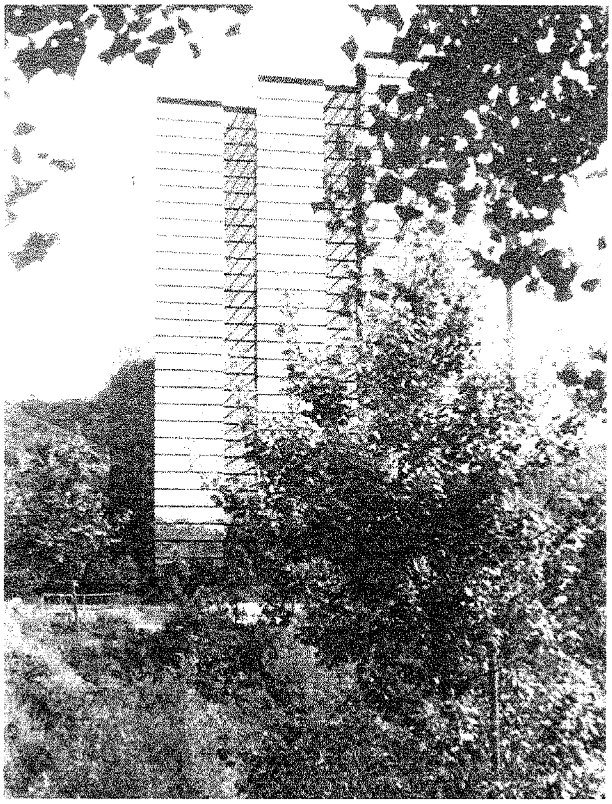


Figure 54. Mitigation of a construction project has resulted in riparian restoration along an urban portion of the San Diego River.

will be affected, work should be phased, where possible, so that small increments are carried out at disjunct locations in order to avoid massive wildlife impacts. While one area is disturbed during activities such as channelization and vegetation removal, wildlife can move to an undisturbed site nearby. After restoration is achieved, wildlife can gradually move back into recovered and restored habitats.

One approach is to allow only a certain percentage of the river reach to be disturbed at any one time. Subsequent phases of a project could not be undertaken until prior phases are completely restored and well established. Phasing decisions should be based on site-specific biological and hydrological data. This approach should reduce the cumulative loss of wildlife habitat that occurs when an entire project is built at once.

7.6.5 Management and Maintenance

A plan for management, maintenance, and monitoring of the project site should be developed at the same time as the restoration plan. Although this may seem an obvious point, most revegetation programs do not include a mechanism for long-term management and maintenance. Once the plants are in the ground, there is a strong tendency to move on to other projects.

To ensure the success of a revegetation program, the plan must include provisions for ongoing maintenance. Typical activities that must be planned for are replacement of diseased and dying plants; maintenance of irrigation systems; protection of young plants from trampling, vandalism, and browsing; control of erosion; judicious use of herbicides, pesticides, and rodenticides; pruning, topping, or removal of vegetation; and any other activities necessary to maintain the site in a condition that meets the original goals of the program (Gray and Lieser, 1982). The plan must specify who will be responsible for carrying out and funding maintenance and management. Generally, the developer will be expected to do this under terms of a maintenance agreement between the developer and the permitting agencies.

7.6.6 Technical Monitoring

A technical monitoring program is essential to judge the success of a revegetation program. This monitoring effort should be specified in the maintenance agreement described above and include a determination of who will be responsible for carrying out the work. Reports should be required for a minimum of 5 years as part of the maintenance agreement and should be sent to the appropriate permitting agencies. Local university students might be involved in annual monitoring as a class project.

Two indicators are typically used to monitor success of revegetation programs: vegetation development and bird usage. Any professional monitoring work should include hydrological data. The emphasis of the monitoring program must be on analysis and conclusions rather than simply the collection of data.

Data collection techniques could include use of aerial infrared photography to map vegetation extent and monitor health. Photos should be taken in spring (May-June) and just before fall dormancy (August-September); they may be used to locate dying trees as well as to assess any stresses affecting the health of the plants, including overdrafting of water tables, increases in upstream diversions, diseases, compaction of soil in root zones, inundation for long periods, and drought. Black-and-white or color photos should also be taken from permanent stations on the ground to provide a record of progress.

Other more traditional techniques for measuring vegetation growth involve transect analysis to determine foliage density, diversity, patchiness, and species-specific growth rate and survival. Methods developed for riparian systems are described in MacArthur and MacArthur (1961) and Anderson and Ohmart (1977). Bird surveys should be conducted to determine nesting, wintering, and migratory uses of the site (Emlen, 1971, 1977; Anderson and Ohmart, 1984).

If vegetation and wildlife are present on the site prior to project development, baseline wildlife and plant data should be collected as a reference point for post-project conditions and revegetation. Another well-established riparian area should be studied and used as a control to compare with the revegetation project.

7.6.7 Milestones for Measuring Progress

The establishment of time lines or milestones for measuring progress is a useful approach. Criteria for setting realistic milestones, however, are not well developed. It is recommended that percentage of plant survival be used as an overall indicator of success. Survival of a given percentage in a specific period of time is the usual method of expression such as 90 percent plant survival 90 days after planting.

Whatever figures are used, this approach must take into account the species being planted and the difficulty of rearing that species. For example, willows would be expected to grow quickly without special attention, whereas small understory plants often need extra protection and care.

Another milestone might be the number of riparian bird species that successfully nest and rear young 3 years after revegetation of a site. Bird, mammal, and other wildlife censuses could be used to measure wildlife use of a control area and a revegetated site. More basic research into wildlife uses of riparian areas is needed before such data can be used to establish reasonable milestones for revegetation projects.

In addition to vegetation health and wildlife uses, monitoring reports could cover topics such as hydraulic efficiency of channels, recovery and stability of channels, and aesthetic and recreational potential. Reports should give some general comments about the overall success of the project along with recommendations for what might be done to improve the project or mitigate problems that have occurred. There is little in the literature on monitoring of restoration work. Revegetation is a young science, especially in California, and monitoring reports will be extremely useful for future restoration efforts.

7.7 A CASE STUDY OF RIPARIAN REVEGETATION

The concept of the First San Diego River Improvement Project (FSDRIP) as a locally sponsored flood-management project evolved from a more traditional Southern California flood-control project design. In 1976 the Corps was approached by local government entities to design a flood-control project for the San Diego River. The initial feasibility studies indicated an unfavorable benefit-to-cost ratio, and the Corps did not proceed. Development of the Mission Valley region continued, however, and it became clear that some kind of flood control was necessary. Local opposition to a traditional channelized waterway was strong, and the alternative of a grass-lined channel was also rejected. In the 1970s property owners along the San Diego River between Highway 163 and Stadium Way began discussing a greenbelt floodway design emphasizing recreation and human use.

The City of San Diego's Planning Department staff was required, under a Corps permit condition suggested by the USFWS, to develop a wetlands management plan for the San Diego River, particularly the stretch flowing through Mission Valley. The result was the 1983 San Diego River Wetlands Management Plan, the primary purpose of which was to establish a means of maintaining and improving the quality of the wetlands associated with the San Diego River while still allowing for development in Mission Valley. A strong goal of the plan was to incorporate biological considerations into planning for development and flood management.

Private developers took the next step and formed their own plan for a portion of the Mission Valley corridor. Their plan, FSDRIP, is a locally proposed combination of flood control, natural area, and parkway. The Corps is involved only as a permitting agency under Section 404 of the Clean Water Act, not as a constructing agency. The City of San Diego, the California Department of Fish and Game, and the USFWS are represented on an advisory committee to oversee the development and implementation of the plan.

In 1983 the FSDRIP plan was approved by the City of San Diego and an EIR was certified. The EIR called for a detailed revegetation plan, which was prepared by Nasland Engineering, Mooney-Lettieri and Associates, and Wier Biological (1984). Although heavily involved in the design of the revegetation plan, and aware that it was prepared by knowledgeable local revegetation biologists, some agency staff remained skeptical about the plan's feasibility. The two main concerns were that the results would not look natural and that the plan would not replace riparian values lost. Some biologists also were concerned about the time required for complete revegetation and the habitat loss and impact on wildlife in the interim.

FSDRIP is a precedent-setting project. No other riparian vegetation plan of this scale has been attempted or proposed in Southern California. Other revegetation plans generally have been associated with park construction, where recreation is the primary purpose and preservation of wildlife habitat secondary or even incidental. The only available model for FSDRIP is work done by Anderson et al. (1984b) in Arizona, who successfully transplanted and revegetated areas using native cottonwoods and who was consulted in connection with the FSDRIP plan. Anderson, however, has not emphasized understory vegetation, and the results have been a form of greenbelt park rather than restoration of a complete riparian ecosystem.

Since no other revegetation efforts of this magnitude have been attempted in California, the FSDRIP plan is designed to provide a model and data base for future riparian restoration efforts. The plan emphasizes specific vegetation development and management milestones with assured funding for remedial measures along with long-term protection. The intent is to mitigate impacts on plants and animals from the channelization of approximately 7,000 ft of the San Diego River in the Mission Valley area. Under this plan, the newly constructed earthen channel would be planted with riparian woodland and freshwater marsh vegetation to enhance its value as wildlife habitat. About 42 acres of woodland and 15 acres of marsh would be created and maintained. Construction was scheduled to begin in late 1986.

The channel has been designed to allow commercial and residential developments approved by the City as part of the FSDRIP project. The channel has been engineered to handle up to the 100-year flood event. It has been designed to function with fully developed riparian vegetation along its banks. Islands constructed in the channel would also be planted with native riparian vegetation. This section of the San Diego River has been subjected to varying degrees of disturbance from sand extraction, fills, unauthorized dumping, and off-road vehicle use. Nevertheless, a considerable amount of wetland habitat still exists along this portion of the river.

The plan anticipates creation of wetland and riparian habitat types typical of native woodlands and marshes. These habitat types are used by wildlife, particularly those species that have declined due to destruction of lowland riparian and freshwater marshes. The emphasis is on including a large number of plant species and a high diversity of stand types with variation in height and density. The plan does not attempt to provide for natural succession of community types. The proposed revegetation would replace lost wetland habitat at a ratio of 1 to 1 or more.

Since the plan was developed in consultation with wildlife management agencies, it provides developers some assurance that, if they adhere to the plan, their projects will be approved. It should also discourage some projects that would overdevelop the floodplain and reduce the friction that now occurs between developers and permitting agencies.

One weakness of the plan is that much of the language requires interpretation by city planners in assessing consistency between the plan and proposed projects. The success of FSDRIP will depend on the dedication of project proponents and government agencies to the principles of the plan. It does, however, allow the City of San Diego to integrate preservation of valuable wetlands into the planning process. Other cities in Southern California will certainly be following the progress of this unique effort; based on the experience of San Diego, they will be able to design their own flood-plain management plans, giving full recognition to the need to include riparian vegetation and wildlife habitat as part of a floodway design. Enforcement is still available through the Fish and Game Code (Section 1600 to 1606) and the Corps 404 Permit Program. The planning process has tended to de-emphasize the proponent's role in the control of the project, but it has assured that funds are available for an adequate program.

7.8 RECOMMENDED REFERENCES

Information on designing revegetation plans can be found in the following documents. All are recommended reading for anyone attempting riparian revegetation.

Nasland Engineering, Mooney-Lettieri and Associates, and Wier Biological. 1984. Revegetation Plan for the First San Diego River Improvement Project (FSDRIP). Nasland Engineering, 4855 Ruffner, San Diego, CA 92111. 38 pp., maps.

An excellent example of a well-designed plan. Includes design criteria and guidelines for site preparation, irrigation, planting, maintenance, and monitoring and lists criteria for river corridor developments.

Stanley, John T., and Winthrop A. Stiles, III. 1983. Revegetation Manual. Alameda County Flood Control and Water Conservation District, 399 Elmhurst Street, Hayward, CA 94544. 183 pp., appendixes.

Includes guidelines for planting plans, irrigation systems, contract specifications, maintenance, plant descriptions, and list of nurseries. Easy to use and well organized.

Smith, Gregory. 1980. Arroyo Conejo Reforestation Report. City of Thousand Oaks, P.O. Box 1496, Thousand Oaks, CA 91360. 79 pp., appendix.

Report on reforestation of a major wastewater pipeline installation. Includes step-by-step discussion of replanting effort, illustrated with before and after photographs, descriptions of plants used, and discussion of follow-up planting after heavy floods.

Gray, Donald, and Andrew T. Leiser. 1982. Biotechnical Slope Protection and Erosion Control. Van Nostrand Reinhold. 271 pp.

Guide to erosion control using vegetation in conjunction with other bank-protection techniques. Covers details of site analysis, species selection, seeds and planting stocks, site preparation, planting techniques, aftercare maintenance. Well written, with case studies and sample designs and specifications for structural components of bank protection.

Schiechtl, Hugo. 1980. Bioengineering for Land Reclamation and Conservation. University of Alberta Press. 404 pp.

Handbook on erosion control and slope protection techniques, including windbreaks, avalanche walls, rockfall barriers, and waterway bank protection. Technical examples, plant selection criteria, common mistakes in bioengineering projects and how to avoid them.

Restoration and Management Notes. Journal published by University of Wisconsin Press, Journals Division, 114 N. Murray Street, Madison, WI 53715.

Described as "a forum for the exchange of news, views, and information among ecologists, land reclamationists, managers of parks, preserves, and rights of way, naturalists, engineers, landscape architects, and others committed to the restoration and wise stewardship of plant and animal communities."

7.9 SOURCES OF PLANTS AND SEEDS

There are many native plant nurseries in California, and a current listing may be obtained from nursery trade magazines and the State Department of Forestry. The USDA Forest Service publishes a list of nurseries and seed suppliers dealing in species used in forest and conservation planting. The USDA Soil Conservation Service and forestry agencies have supplies of some native shrubs and forest trees. California Department of Water Resources Bulletin No. 209 lists plants for California landscapes.

Lists of native plant nurseries and seed suppliers are published in the Revegetation Manual (Alameda County, 1983) and the Arroyo Conejo Reforestation Report (G. Smith, 1980). The California Native Plant Society journal, Fremontia, contains articles on native species and also runs advertisements for nurseries and seed suppliers. The Saratoga Horticultural Foundation publishes Selected California Native Plants with Commercial Sources.

7.10 SUMMARY

There is increasing interest in protecting and restoring riparian habitat in Southern California, but these efforts are complicated by highly fragmented land ownership patterns and conflicts with flood-control objectives. Mitigation measures in project permits are often inadequate or are not carried out at all. Successful restoration work requires early agreement on project goals, site-specific restoration design, correct project implementation, enforcement of permit conditions, a maintenance and management program, and long-range monitoring.

REFERENCES

Aitchison, S.W. 1977. Some effects of a campground on breeding birds in Arizona. U.S. For. Serv. Gen. Tech. Rep. RM-43:175-182.

Alameda County. 1983. Revegetation Manual for the Alameda County Flood Control and Water Conservation District Revegetation Program. Hayward. 184 pp.

American Fisheries Society. 1970. A list of common and scientific names of fishes from the United States and Canada.

American Ornithologists Union (AOU). 1983. Check-list of North American birds, 6th ed. Allen Press, Inc., Lawrence, KS. 877 pp.

Ames, C.R. 1977. Wildlife conflicts in riparian management: grazing. U.S. For. Serv. Gen. Tech. Rep. RM-43:49-51.

Anderson, B.W., and R.D. Ohmart. 1977. Vegetation structure and bird use in the lower Colorado River Valley. Pages 23-34 in R.R. Johnson and D.A. Jones, eds. Symposium proceedings: importance, preservation, and management of riparian habitat. U.S. For. Serv. Gen. Tech. Rep. RM-43.

Anderson, B.W., and R.D. Ohmart. 1984. Avian use of revegetated riparian zones. Pages 626-634 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Anderson, B.W., R.D. Ohmart, and H.A. Allen, Jr. 1984. Riparian birds in the riparian/agricultural interface. Pages 190-196 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Anderson, B.W., R.D. Ohmart, and J. Disano. 1978. Revegetating the riparian floodplain for wildlife. Pages 318-331 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Anderson, B.W., J. Disano, D.L. Brooks, and R.D. Ohmart. 1984. Mortality and growth of cottonwood on dredge-spoil. Pages 438-444 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Anderson, N.H., and K.W. Cummins. 1979. Influences of diet on the life histories of aquatic insects. J. Fish. Res. Board Canada 36:335-342.

Andrews, E.D. 1979. Scour and fill in a stream channel, East Fork River, western Wyoming. U.S. Geol. Surv. Prof. Pap. 1117. 49 pp.

Atwood, J.L., and D.E. Minsky. 1983. Least tern foraging ecology at three major California breeding colonies. West. Birds 14:57-71.

Axelrod, D.I. 1950. The Piru Gorge flora of Southern California. Carnegie Inst. Wash. Publ. 590:159-224.

Axelrod, D.I. 1967. History of the coniferous forests, California and Nevada. Univ. Calif. Publ. Bot. 70:1-62.

Bailey, F.M. 1902. Handbook of birds of the Western United States. Houghton Mifflin Co. The Riverside Press, Cambridge. 570 pp.

Baltz, D.M., and P.B. Moyle. 1984. The influence of riparian vegetation on stream fish communities of California. Pages 183-187 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Barbour, R.W., and W.H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington. 286 pp.

Beidleman, R.G. 1948. The vertebrate ecology of a Colorado cottonwood river bottom. M.A. Thesis. University of Colorado, Boulder. 351 pp.

Belloumini, L.A. 1983. Ringtail (Bassariscus astutus) distribution and abundance in the Central Valley of California. M.S. Thesis. California State University, Sacramento.

Bent, A.C. 1921-1985. Life histories of North American birds. Dover Publications, New York.

Best, L.B., and D.F. Stauffer. 1980. Factors affecting nesting success in riparian bird communities. Condor 82(2):149-158.

Bierman, G.C., and S.G. Sealy. 1980. Parental feeding of nestling Yellow Warblers in relation to brood size and prey availability. Auk 99:332-342.

Billings, W.D. 1978. Plants and the ecosystem. Wadsworth Publishing Co., Belmont, CA. 177 pp.

Bleich, V.C. 1973. Ecology of rodents at the U.S. Naval Weapons Station Seal Beach, Fallbrook Annex, U.S. Fish and Wildlife Service, San Diego, CA. 43 pp.

Bond, S.K. 1977. An annotated list of the mammals of San Diego County, CA. Trans. San Diego Soc. Nat. Hist. 18:229-248.

Bormann, F.H., and G.E. Likens. 1977. The fresh air-clean water exchanges. Nat. Hist. 86(9):62-71.

Bottorff, R.L. 1974. Cottonwood habitats for birds in Colorado. Am. Birds 28(6):975-979.

Boussu, M.F. 1954. Relationship between trout populations and cover on a small stream. J. Wildl. Manage. 18(2):229-239.

Brothers, T.S. 1984. Historical vegetation change in the Owens River riparian woodland. Pages 75-84 in R.E. Warner and K.M. Hendrix, eds. 1984. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Brown, G.W., and J.T. Krygier. 1967. Changing water temperatures in small mountain streams. J. Soil and Water Conserv. 22(6):242-244.

Brown, G.W., and J.T. Krygier. 1970. Effects of clear-cutting on stream temperature. Water Res. 6:1133-1139.

Brown, G.W., G.W. Swank, and J. Rothacher. 1971. Water temperature in the Steamboat drainage. U.S. For. Serv. Res. Pap. PNW-119. 17 pp.

Brownlie, W.R., and B.D. Taylor. 1981. Sediment management for southern California mountains, coastal plains, and shoreline. Calif. Inst. Technol. EQL Rep. 17-C. 314 pp.

Brucs, C.T. 1946. Insects, food, and ecology. Dover Publications, New York. 154 pp.

Burt, W.H., and R.P. Grossenheider. 1964. A field guide to the mammals. Houghton Mifflin Co., Boston. 284 pp.

Bury, R.B. 1972. Habits and home range of the Pacific pond turtle (Clemmys marmorata) in a stream community. Ph.D. Thesis. University of California, Berkeley.

Busby, D.G., and S.G. Sealy. 1979. Feeding ecology of a population of nesting Yellow Warblers. Can. J. Zool. 57:1670-1681.

California Council on Intergovernmental Relations [now absorbed into Office of Planning and Research]. 1970. Allocation of public service responsibilities. California Department of Fish and Game, Sacramento.

Campbell, C.J., and W. Green. 1968. Perpetual success of stream-channel vegetation in a semi-arid region. J. Ariz. Acad. Sci. 5(2):86-98.

Campbell, J.C. 1970. Ecological implications of riparian vegetation management. J. Soil Water Conserv. 25(2):49-52.

Campbell, B. 1980. Some mixed hardwood forest communities of the coastal ranges of Southern California. Phytocoenologia 8:297-320.

Capelli, M.H., and S.J. Stanley. 1984. Preserving riparian vegetation along California's south central coast. Pages 673-677 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Carothers, S.W. 1977. Importance, preservation and management of riparian habitat: an overview. U.S. For. Serv. Gen Tech. Rep. 43. 217 pp.

Carothers, S.W., and R.R. Johnson. 1977. Some ecological considerations associated with river recreation management. Pages 222-225 in Proceedings: river recreation, management, and research symposium. U.S. For. Serv. Gen. Tech. Rep. NC-28.

Carothers, S.W., and R. Nolan. 1982. Dam changes of the Colorado River. Nat. His. 91(1):74-84.

Chaney, R.W., and H.L. Mason. 1930. A pleistocene flora from Santa Cruz Island, California. Carnegie Inst., Wash. Publ. No. 415, pp. 1-24.

Chapman, D.W., and R.L. Demory. 1963. Seasonal changes in the food ingested by aquatic insect larvae and nymphs in two Oregon streams. Ecology 44:140-146.

Cody, M., and H. Mooney. 1978. Convergence versus nonconvergence in mediterranean climate ecosystems. Annu. Rev. Ecol. Syst. 9:265-321.

Cole, F.R. 1969. The flies of Western North America. University of California Press, Berkeley. 693 pp.

Collings, M.R., and R.M. Myrick. 1966. Effects of juniper and pinyon eradication onstream flow from Corduroy Creek Basin, Arizona. U.S. Geol. Surv. Prof. Pap. 491-B. 12 pp.

Collins, J.T., J.E. Huheey, J.L. Knight, and H.M. Smith. 1978. Standard common and current scientific names for North American amphibians and reptiles. Herpet. Soc. Cir. 7. 36 pp.

Cordone, A.J., and D.E. Kelley. 1961. The influence of inorganic sediment on the aquatic life of streams. Calif. Dep. Fish Game 47(2):189-228.

Cowardin, L.M., V. Carter, F. Golet, and E.T. LaRoe. 1977. Classification of wetlands and deep-water habitats of the United States. U.S. Fish Wildl. Serv. FWS/OBS-79/31. 103 pp.

Cummins, K.W. 1973. Trophic relations of aquatic insects. Ann. Rev. Ent. 18:183-206.

Cummins, K.W. 1974. Structure and function of stream ecosystems. Bioscience 24:631-641.

Cummins, K.W. 1975. The ecology of running water; theory and practice. Pages 277-293 in H.B. Hynes, ed. Proceedings of Sandusky River Basin symposium. International Joint Commission of the Great Lakes. Heidleberg College, Tiffin, OH.

Dawson, K.J. 1984. Planting design inventory techniques for modeling the restoration of native riparian landscapes. Pages 465-470 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Day, W.C. 1956. Ephemeroptera. Pages 79-105 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Department of Water Resources, The Resources Agency, State of California. 1980. California flood management: An evaluation of flood damage prevention programs. Calif. Dep. Water Res. Bull. 199. 277 pp.

Detwiler, P.M. 1980. Public works or public policy: what guides new development in California? Calif. Off. Plan. Res. J. 3(1):34-44.

Dick-Peddie, W.A., and J.P. Hubbard. 1977. Classification of riparian vegetation. U.S. For. Serv. Gen. Tech. Rep. RM-43:89-90.

Dorst, J. 1974. The life of birds. Columbia University Press, New York. 717 pp.

Dumas, P.C. 1950. Habitat distribution of breeding birds in southeastern Washington. Condor 52(5):232-237.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman Co., San Francisco. 818 pp.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. The mayflies of North America. University of Minnesota Press, Minneapolis. 330 pp.

Emerson, K.C. 1964. Checklist of the Mallophage of North America. Pt 1. Suborder: Ischnocera, Pt 2. Suborder: Amblycera. Dugway Proving Ground. Dugway, UT.

Emlen, J.T. 1971. Population densities of birds derived for transect counts. Auk 88:323-342.

Emlen, J.T. 1977. Estimating breeding bird densities from transect counts. Auk 94:455-468.

Emmel, T.C., and J.F. Emmel. 1973. The butterflies of Southern California. Nat. Hist. Mus. Los Ang. Cty. Sci. Ser. 26.

Emmerich, J.M., and P.A. Vohs. 1982. Comparative use of four woodland habitats by birds. J. Wildl. Manage. 46(1):43-49.

Englebert, E.A. 1979. California water planning and policy--selected issues. University of California, Kellogg Foundation. June 1979.

Environmental Protection Agency (EPA). 1972. Don't leave it to the experts. U.S. Government Printing Office. 1972 0-478-748.

Erman, D.C., J.D. Newvold, and K.B. Roby. 1977. Evaluation of streamside bufferstrips for protection of aquatic organisms. Water Resources Center Contract 165. University of California, Davis. 45 pp.

Erman, N.A. 1984. The use of riparian systems by aquatic insects. Pages 177-182 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Essig, E.O. 1926. Insects of North America. The Macmillan Co., New York. 1035 pp.

Farmer, A.H. 1979. Development of mitigation alternatives: a process. Pages 327-330 in G.A. Swanson, tech. coord. The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats. U.S. For. Serv. Gen. Tech. Rep. RM-65.

Fenner, P., W.W. Brady, and D.R. Patton. 1984. Observations on seeds and seedlings of Fremont cottonwood. Desert Plants 6(1):55-58.

Ferren, W.R., Jr. 1983. The vegetation and flora of the streams and slough. In C.P. Onuf, ed. The proposed Corps of Engineers flood control and ground water recharge project for the Goleta Valley, Santa Barbara County, California: inventories of the biological resources of the affected creeks and an analysis of effects on the creeks and the slough. Prepared for the U.S. Army Corps of Engineers, Santa Barbara.

Fisher, R., and W. Ury. 1984. Getting to yes. Negotiating agreement without giving in. Penguin Books, New York. 161 pp.

Fitch, H.S., F. Swenson, and D.F. Tillotson. 1946. Behavior and food habits of the red-tailed hawk. Condor 48(5):205-237.

Fletcher, M. 1983. A flora of Hollister Ranch, Santa Barbara County, CA. The Herbarium, Dep. of Biol. Sci. University of California, Santa Barbara, Publ. No. 2.

Frenkel, R.E. 1970. Ruderal vegetation along some California roadsides. Univ. Calif. Publ. Geogr. 20:1-163.

Friedman, H., L.F. Kiff, and S.I. Rothstein. 1977. A further contribution to knowledge of the host relations of the parasitic cowbirds. Smithsonian Contrib. Zool. 235. 75 pp.

Gaines, D. 1974. A new look at the nesting riparian avifauna of the Sacramento Valley, California. West. Birds 5:61-80.

Gaines, D.A. 1977. The valley riparian forests of California: their importance to bird populations. Pages 57-85 in A. Sands, ed. Riparian forest in California: ecology and conservation. Inst. Ecol. Publ. 15, University of California, Davis.

Garrett, H., and J. Dunn. 1981. Birds of Southern California: status and distribution. Los Angeles Audubon Society.

Goldner, B.H. 1984. Riparian restoration efforts associated with structurally modified flood control channels. Pages 445-451 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation and productive management. University of California Press, Berkeley.

Goldwasser, S., D. Gaines, and S.R. Wilbur. 1980. The Least Bell's Vireo in California: a de facto endangered race. Am. Birds 34:743-745.

Gray, D.H., and A.T. Leiser. 1982. Biotechnical slope protection and erosion control. Van Nostrand Reinhold, New York. 271 pp.

Gray, M.V., and J. Greaves. 1984. The riparian forest as habitat for the Least Bell's Viero (Vireo bellii pusillus). Pages 605-611 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Graynoth, E. 1979. Effects of logging on stream environments and faunas. N.Z. J. Mar. Freshwater Res. 13:79-109.

Greenfield, D.W., S.T. Ross, and G.D. Deckert. 1970. Some aspects of the life history of the Santa Ana sucker, Catostoma (Pantosteus) santaanea (Snyder). Calif. Dep. Fish Game Fish Bull. 56:166-179.

Griffin, J.R., and W.B. Critchfield. 1972. The distribution of forest trees in California. U.S. For. Serv. Pap. PSW-82. 114 pp.

Grigarick, A.A., and L.A. Stange. 1968. The pollen collecting bees of the Anthidini of California (Hymenoptera: Magachilidae). Bull. Calif. Insect Surv. 9:1-113.

Grinnel, J. 1898. Birds of the Pacific slope of Los Angeles County. Pasadena Acad. Sci. Publ. 2.

Grinnell, J. 1908. The biota of the San Bernardino Mountains. Univ. Calif. Publ. Zool. 5:1-170.

Grinnell, J. 1933. Review of the Recent mammal fauna of California. Univ. Calif. Publ. Zool. 40(2):71-234.

Grinnell, J., and A.H. Miller. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27. Cooper Ornith. Club, Berkeley.

Gunderson, D.R. 1968. Floodplain use related to stream morphology and fish populations. J. Wildl. Manage. 32(3):507-514.

Gustafson, J.R. 1975. Winter bird census, riparian woodland, El Capitan State Beach. Am. Birds 29:765-766.

Hack, J.T. 1960. Interpretation of erosional topography in humid temperate regions. Am. J. Sci. 258:80-97.

Hall, E.R. 1981. Mammals of North America. John Wiley & Sons, New York. Vol. 1 and 2.

Hamilton, M. 1983. A floristic basis for the management of rare species and their communities in the San Jacinto Mountains, Calif. James San Jacinto Mountains Reserve, Idyllwild.

Hanes, T.L. 1976. Vegetation types of the San Gabriel Mountains. Pages 65-77 in J. Latting, ed. Symposium proceedings: plant communities of Southern California. Calif. Native Plant Soc. Spec. Publ. No. 2.

Harris, R.W., A.T. Leiser, and R.E. Fissell. 1979. Tolerance of oaks to flooding. U.S. Pacific Southwest Forest and Range Experiment Station, Berkeley.

Harrison, C. 1979. A field guide to the nests, eggs and nestlings of North American birds. Wm. Collins Sons & Co. Ltd., Glasgow. 416 pp.

Hart, S.D. 1975. The decomposition of leaves in two Southern California streams. Master's Thesis. University of California, Santa Barbara.

Heberlein, T.A. 1977. Density, crowding, and satisfaction: Sociological studies for determining carrying capacities. Pages 67-76 in Proceedings: river recreation, management, and research symposium. U.S. For. Serv. Gen. Tech. Rep. NC-28.

Herbkersman, C.N. 1982. A guide to the George Palmiter River restoration techniques. Institute of Environmental Sciences, Miami University, Oxford, OH. 52 pp.

Higgins, E.B. 1949. Annotated distributional list of the ferns and flowering plants of San Diego County, California. San Diego Soc. Nat. Hist. Occas. Pap. 8. 50 pp.

Hinschberger, M.S. 1978. Occurrence and relative abundance of small mammals associated with riparian and upland habitats along the Columbia River. Master's Thesis. Oregon State University, Corvallis. 78 pp.

Hogue, C.L. 1974. The insects of the Los Angeles Basin. Nat. Hist. Mus. Los Ang. Cty. Sci. Ser. 27. 173 pp.

Holstein, G. 1984. California riparian forests: deciduous islands in an evergreen sea. Pages 2-22 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Horton, J.S. 1972. Management problems in phreatophyte and riparian zones. J. Soil Water Conserv. 27(2):57-61.

Hosner, J.F. 1958. The effects of complete inundation upon seedlings of six bottomland tree species. Ecology 39:371-373.

Hosner, J.F. 1960. Relative tolerance to complete inundation of fourteen bottomland tree species. For. Sci. 6:146-251.

Howell, J.F. 1929. The flora of the Santa Ana Canyon region. Madrono 1:243-253.

Hubbard, J.P. 1977. Importance of riparian ecosystems: biotic considerations. Pages 14-18 in R.R. Johnson and D.A. Jones, eds. Symposium proceedings: importance, preservation and management of riparian habitat. U.S. For. Serv. Gen. Tech. Rep. RM-43.

Hubbs, C.L., R.R. Miller, and L.C. Hubbs. 1974. Hydrographic history and relict fishes of the north central Great Basin. Mem. Calif. Acad. Sci. 7. 259 pp.

Hynes, H.B.N. 1970. The ecology of running water. University of Toronto Press, Toronto. 555 pp.

Ingles, L.G. 1929. The seasonal and associational distribution of the fauna of the upper Santa Ana River wash. J. Ent. Zool. 21:1-96.

Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, CA. 506 pp.

Irvine, J.R., and N.E. West. 1979. Riparian tree species distribution and succession along the lower Escalante River, Utah. Southwest. Nat. 24(2):331-346.

Jahn, L.R. 1978. Values of riparian habitats to natural ecosystems. Pages 157-160 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For Serv. Gen. Tech. Rep. WO-12.

Jain, S. 1976. Vernal pools: their ecology and conservation. Univ. Calif. Inst. Ecol. Publ. 9. 93 pp.

Jenks, J.S., T.C. MacDonald, and J.P. Grath. 1984. Pages 405-413 in North city west drainage study: urban stormwater management in coastal areas. A.S.C.E., Blackburg, VA.

Jepson, W.L. 1923. The silva of California. University of California, Berkeley. Mem. Vol. 2. 480 pp.

Jewett, S.G., Jr. 1956. Plecoptera. Pages 155-181 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

John Muir Institute. 1979. Erosion and sediment in California watersheds: a study of institutional controls. June 1979. John Muir Institute, Berkeley. 102 pp.

Johnson, R.R., L.T. Haight, and J.M. Simpson. 1977. Endangered species versus endangered habitats: a concept. U.S. For. Serv. Gen. Tech. Rep. RM-43:79.

Jones, B.E. 1982. Report on California governmental programs and legislation affecting water-related resources. California Resources Agency, Sacramento.

Jordan, W.R., III. 1984. Working with the river (The George Palmiter approach). Restoration Manage. Notes 2(1):4-10.

Karr, J.R., and I.J. Schlosser. 1978. Water resources and the land-water interface. Science 201:229-234.

Keeney, T., and S. Loe. 1984. California wildlife and their habitats: Southern California. U.S. Forest Service.

Keller, E.A. 1971. Areal sorting of bed-load material: the hypothesis of velocity reversal. Geol. Soc. Am. Bull. 82:753-756.

Keller, E.A. 1976. Channelization: environmental, geomorphic and engineering aspects. Pages 115-140 in D.R. Coates, ed. Geomorphology and engineering. Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA.

Keller, E.A. 1977. The fluvial system: selected observations. In A. Sands, ed. Riparian forests in California: their ecology and conservation. Univ. Calif. (Davis) Inst. Ecol. Publ. 13--reprinted 1980 Univ. Calif. (Berkeley) Agric. Sci. Publ. 4101.

Keller, E.A., and W.N. Melhorn. 1973. Bedforms and fluvial processes in alluvial stream channels: selected observations. Pages 253-284 in M. Murisawa, ed. Fluvial geomorphology. State University of New York, Binghamton.

Kelly, W., R. Hubbell, S. Loe, and L. Shikany. 1975. Management of riparian habitats. U.S. For. Serv. Coord. Guides Wildl. Hab. 9:9.

Kennedy, C.E. 1977. Wildlife conflicts in riparian management: water. U.S. For. Serv., Gen. Tech. Rep. RM-43:52-58.

Kibby, H.V. 1978. Effects of wetlands on water quality. Pages 289-298 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Kirby, R.E. 1975. Wildlife utilization of beaver flowages on the Chippewa National Forest, North Central Minnesota. Loon 47(4):180-185.

Knight, A.W., and R.L. Bottorff. 1984. The importance of riparian vegetation to stream ecosystems. Pages 160-167 in R.F. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Kondolf, G.M., and R.R. Curry. 1984. The role of riparian vegetation in channel bank stability, Carmel River, California. Pages 124-133 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Kusler, J.A. 1978. Regulating critical riparian lands: a challenge in inter-governmental cooperation. Pages 332-335 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Lange, W.H., Jr. 1956. Aquatic Lepidoptera. Pages 271-288 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

La Rivers, I. 1956. Aquatic Orthoptera. Pages 154 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Lathrop, E.W., and R.F. Thorne. 1968. Flora of the Santa Rosa Plateau of the Santa Ana Mountains, California. Aliso 6(4):17-40.

Lathrop, E.W., and R.F. Thorne. 1978. A flora of the Santa Ana Mountains, California. Aliso 9(2):197-278.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. Biol. Surv. Publ. 1980-12, NC.

Leech, H.B., and H.P. Chandler. 1956. Aquatic Coleoptera. Pages 293-371 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Lehman, P. 1982. Status and distribution of the birds of Santa Barbara County, CA. M.A. Thesis. University of California, Santa Barbara.

Leliavsky, S. 1966. An introduction to fluvial hydraulics. Dover Publications, New York. 351 pp.

Leopold, L.B., and T. Maddock, Jr. 1953. The hydraulic geometry of stream channels and some physiographic implications. U.S. Geol. Surv. Proj. Pap. 252. 57 pp.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman, San Francisco, CA.

Lewis, D.E., and G.G. Marsh. 1977. Problems resulting from the increased recreational use of rivers in the west. Pages 27-31 in Proceedings: river recreation, management, and research symposium. U.S. For. Serv. Gen. Tech. Rep. NC-28.

Lieth, H., and R.H. Whittaker. 1975. Primary productivity of the biosphere. Springer-Verlag, New York.

Likens, G.E., F.H. Bormann, D.W. Fisher, and R.S. Pierce. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook Watershed-ecosystem. Ecol. Monog. 40:23-47.

Lines, I.L., Jr., J.R. Carlson, and R.A. Corthell. 1978. Repairing flood-damaged streams in the Pacific Northwest. Pages 195-200 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Lisle, T. 1979. A sorting mechanism for a riffle pool sequence. Geol. Soc. Am. Bull. 90:1142-1157.

Long, M.C. 1982. White alder (Alnus rhombifolia) regrowth following 1968-1969 floods. Crossosoma. Rancho Santa Ana Botanic Garden, Claremont. Vol. 8(1):1-3.

MacArthur, R.H., and J.W. MacArthur. 1961. On bird species diversity. Ecology 42(3):594-598.

Maddock, T., Jr. 1969. The behavior of straight open channels with movable beds. U.S. Geol. Surv. Prof. Pap. 622A. 70 pp.

Mahoney, D.L., and D.C. Erman. 1984. The role of streamside bufferstrips in the ecology of aquatic biota. Pages 168-176 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Marsh, G.A., and K.D. Abbott. 1972. Plants and animals of the Santa Ana River in Orange County. Orange County Flood Control District, Santa Ana.

Maximov, N.S. 1931. The physiological significance of the xeromorphic structure of plants. J. Ecol. 19(2):273-282.

McAtee, W.L. 1932. Effectiveness in nature of the so-called protective adaptations in the animal kingdom, chiefly as illustrated by the food habits of Nearctic birds. Smithson. Misc. Collect. 85:7.

McBride, J.R., and J. Strahan. 1984. Fluvial processes and woodland succession along Dry Creek, Sonoma County, California. Pages 110-120 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

McFarlane, R.W. 1976. Birds as agents of biological control. Biologist 58:123-140.

McKeown, M.S. 1974. Checklist of amphibians and reptiles of Santa Barbara County. Santa Barbara Mus. Nat. Hist. Occas. Pap. 9.

McMinn, E., and E. Maino. 1967. An illustrated manual of Pacific coast trees. University of California Press, Berkeley. 409 pp.

McNichol, D.K. 1982. Seasonal, habitat and sex-specific food habits of red-winged blackbirds: implications for agriculture. Can. J. Zool. 60:3282-3289.

Mecom, J.O. 1972. Feeding habits of Trichoptera in a mountain stream. Oikos 23:401-407.

Meents, J.K., B.W. Anderson, and R.D. Ohmart. 1984. Sensitivity of riparian birds to habitat loss. Pages 619-625 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Menke, A.S. 1979. The semi-aquatic and aquatic Hemiptera of California (Heteroptera:Hemiptera). Bull. Calif. Insect Surv. 21:1-166.

Merritt, R.W., and K.W. Cummins, editors. 1978. An introduction to the aquatic insects of North America. Kendall Hunt Publ. Co., Dubuque. 441 pp.

Merritt, R.W., and D.L. Lawson. 1978. Leaf littering processing in floodplain and stream communities. In R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Rep. WO-12.

Miller, A.H. 1951. An analysis of the distribution of the birds of California. Univ. Calif. Publ. Zool. 50(6):531-644.

Miller, R.R. 1960. The type locality of Gasterosteus aculeatus williamsoni and its significance in the taxomony of California sticklebacks. Copeia (4):348-350.

Miller, R.R. 1968. Records of some native freshwater fishes transplanted into various waters of California, Baja California, and Nevada. Calif. Dep. Fish Game Fish Bull. 54:170-179.

Minnich, R.A. 1976. Vegetation of the San Bernardino Mountains. Pages 99-125 in J. Latting, ed. Symposium proceedings: plant communities of Southern California. Calif. Native Plant Soc. Spec. Publ. 2.

Minnich, R.A. 1980. Vegetation of Santa Cruz and Santa Catalina Islands. Pages 123-137 in D.M. Power, ed. The California Islands: proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History.

Minore, D. 1970. Seedling growth of eight northwestern tree species over three water tables. U.S. For. Serv. Res. Note PNW-113. 9 pp.

Mooney-Lettieri and Associates. 1984. Final EIR/EA for the Pamo Reservoir. Vol. 1. San Diego County Water Authority.

Moring, J.R. 1975. The Alsea watershed study: effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part II. Oreg. Dep. Fish Wildl. Fish. Res. 9. 91 pp.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley. 405 pp.

Mudie, P. 1969. Survey of coastal vegetation of northern San Diego County. California Department of Fish and Game.

Munz, P.A. 1974. A flora of Southern California. University of California Press, Berkeley. 1086 pp.

Munz, P.A., and D.D. Keck. 1968. A California flora. University of California Press, Berkeley. 1681 pp.

Nasland Engineering, Mooney-Lettieri, and Wier Biological. 1984. Revegetation plan for the First San Diego River Improvement Project (FSDRIP). 38 pp.

National Association of Conservation Districts (NACD). 1980. The role of conservation districts in the coastal zone management program. Office of Coastal Zone Management, Natl. Oceanic Atmosph. Admin. U.S. Dep. Commerce.

Needham, J.G., and M.J. Westfall. 1955. A manual of the dragonflies of North America. University of California Press, Berkeley. 615 pp.

Nunnally, N.R. 1978. Improving channel efficiency without sacrificing fish and wildlife habitat: the case for stream restoration. Pages 394-399 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Odum, E.P. 1978. Ecological importance of the riparian zone. Pages 2-4 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Odum, W.G., T.J. Smith, III, J.K. Hoover, and C.C. McIvor. 1984. The ecology of tidal freshwater marshes of the United States east coast: a community profile. U.S. Fish Wildl. Serv. FWS/OBS-83/17. 177 pp.

Ohmart, R.D., and R.W. Anderson. 1977. North American desert riparian ecosystems. Pages 433-467 in G.L. Bender, ed. Reference handbook of the deserts of North America. 1982. Greenwood Press, Westport, CT.

Ohmart, R.D., and R.W. Anderson. 1980. Wildlife use values of wetlands in the arid Southwestern United States. Proc. Natl. Symp. Wetlands.

Onuf, C.P. 1983. The proposed U.S. Army Corps of Engineers flood control and general ground water recharge project for the Goleta Valley, Santa Barbara County, CA: inventories of the biological resources of the affected creeks and a preliminary analysis of possible effects including the Goleta Slough. U.S. Army Corps of Eng., Los Angeles, CA.

Ornduff, R. 1974. An introduction to California plant life. University of California Press, Berkeley. 152 pp.

Patton, D.R. 1975. A diversity index for quantifying "edge." Wildl. Soc. Bull. 3(4):171-173.

Peattie, D.C. 1953. A natural history of western trees. Bonanza Books, New York. 751 pp.

Pequegnat, W.E. 1951. The biota of the Santa Ana Mountains. J. Ent. Zool. 42:1-84.

Perkins, P.D. 1976. Psammophilous aquatic beetles in southern California: a study of microhabitat preferences with notes on responses to stream alteration (Coleoptera: Hydraenidae and Hydrophilidae). Coleopt. Bull. 30:309-324.

Peterson, A. 1967. Larvae of insects. 6th ed. 2 vol. Edwards Brothers, Ann Arbor, MI.

Philbrick, R.N., and J.R. Haller. 1977. The Southern California Islands. Pages 893-909 in M.G. Barbour and J. Major, eds. Terrestrial vegetation of California. John Wiley & Sons, New York.

Phillips, W.S. 1963. Depths of roots in soil. Ecology 44:424.

Pinkowski, B. 1978. Feeding of nestling and fledgling eastern bluebirds. Wilson Bull. 90:84-98.

Powell, J.A., and C.L. Hogue. 1979. California insects. University of California Press, Berkeley. 388 pp.

Prunuske, E., and H. Morrison. 1982. Final report, California Department of Water Resources urban streams cleanup and restoration program. Circuit Rider Productions, Windsor, CA.

Raven, P.H., and H.J. Thompson. 1966. Flora of the Santa Monica Mountains, California. University of California, Los Angeles. 189 pp.

Remsen, J.V., Jr. 1979. Species of special concern: California's imperiled birds. West. Tanager 45(8):1-8.

Riley, A., and A. Sands. 1984. The design and planning approach to flood damage reduction--a way to restore the riparian environment. Pages 82-86 in J.P. Rieger and B.A. Steele, eds. Symposium proceedings: native plant revegetation symposium. California Native Plant Society, San Diego Natural History Museum, San Diego.

Robichaux, R. 1977. Geologic history of the riparian forests of California. Pages 21-34 in A. Sands, ed. Riparian forests in California, their ecology and conservation. Univ. Calif. (Davis), Inst. Ecol. Publ. 15.--reprinted 1980 Univ. Calif. (Berkeley) Agric. Sci. Publ. 4101.

Robinson, J. 1953. A taxonomic and ecological study of the flora of the San Gabriel River Canyon. Master's Thesis. Whittier College, Whittier, CA.

Robinson, T.W. 1965. Introduction, spread and a real extent of salt cedar (Tamarix) in the western states. U.S. Geol. Surv. Pap. 491-A. 15 pp.

Robinson, T.W. 1985. Phreatophytes. U.S. Geol. Surv. Water Supply Pap. 1423. 52 pp.

Rosenberg, K.V., R.D. Ohmart, and B.W. Anderson. 1982. Community organization of riparian breeding birds: response to an annual reserve peak. Auk 99:260-274.

Rothstein, S.I., J. Verner, and E. Stevens. 1980. Range expansion and diurnal changes in dispersion of the brown-headed cowbird in the Sierra Nevada. Auk 97:253-268.

Rundel, P. 1980. Adaptions of mediterranean-climate oaks to environmental stress. Pages 43-54 in T. Plumb., tech. coord. Proceedings of the symposium on the ecology, management, and utilization of California oaks. Claremont, CA. U.S. For. Serv. Gen. Tech. Rep. PSW-44. 368 pp.

Salata, L.R. 1983. Status of the Least Bell's Vireo within the Santa Margarita project area. U.S. Fish and Wildlife Service, Laguna Niguel, CA.

Scheid, G.A. 1985 (draft). Habitat characteristics of willowy monardella, Monardella linoides ss. Uiminea, in San Diego County. Prepared for CALTRANS. 40 pp.

Schiechtl, H. 1980. Bioengineering for land reclamation and conservation. University of Alberta Press, Edmonton, Canada. 404 pp.

Schmidly, D.J., and R.B. Ditton. 1978. Relating human activities and biological resources in riparian habitats in western Texas. Pages 107-117 in R.R. Johnson and J.F. McCormick, tech. coords. Symposium proceedings: strategies for protection and management of floodplain wetlands and other riparian ecosystems, Callaway Gardens, GA. U.S. For. Serv. Gen. Tech. Rep. WO-12.

Schoenherr, A. 1976. Herpetofauna of the San Gabriel Mountains. Southwestern Herpetologists' Society.

Schumm, S.A., and H.R. Kahn. 1972. Experimental study of channel patterns. Geol. Soc. Am. Bull. 83:1755-1770.

Schwabe, J., G. Gavin, B. Ford, and R. Blyther. 1984. Prairie Creek habitat restoration plan. A project of the Redwood Community Action Agency. California State Coastal Conservancy, Oakland. 10 pp.

Short, C., and M. Schamberger. 1979. Evaluation of impacts on fish and wildlife habitat and development of mitigation measures. Pages 331-335 in G.A. Swanson, tech. coord. The mitigation symposium: a national workshop on mitigation losses of fish and wildlife habitats. U.S. For. Serv. Gen. Tech. Rep. RM-65.

Shute, E.C., Jr., and B. Mihaly. 1981. Analysis of powers exercised by regulatory agencies over diked wetlands and recommendations, report to Bay Conservation and Development Commission, September 30, 1981. San Francisco.

Simons, D.B., and E.V. Richardson. 1966. Resistance to flow in alluvial channels. U.S. Geol. Surv. Prof. Pap. 422-J.

Sloan, A.J. 1964. Amphibians of San Diego County. San Diego Soc. Nat. Hist. Occas. Pap. 13.

Small, A. 1974. The birds of California. Winchester Press, New York. 309 pp.

Smith, C.F. 1976. A flora of the Santa Barbara Region, California. Santa Barbara Museum of Natural History. 331 pp.

Smith, G. 1980. Arroyo Conejo reforestation report. City of Thousand Oaks Planning Department. 83 pp.

Smith, J.P., Jr., and R. York. 1984. Inventory of rare and endangered vascular plants of California. California Native Plant Society, Sacramento, CA 95814.

Smith, R.F., and A.E. Pritchard. 1956. Odonata. Pages 106-153 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Smith, R.L. 1979. Santa Clara sand and gravel master study. Final environmental impact report. Envicom Corp. (contractors) Nov. 28, 1979. Ventura County Resource Management Agency.

Smith, R.L. 1980. Alluvial scrub vegetation of the San Gabriel River floodplain, California. Madrono 27 (3):126-138.

Stanley, J.T., and W.A. Stiles, III. 1983. Revegetation manual for the Alameda County Flood Control and Water Conservation District revegetation program. Hayward, CA. 211 pp.

State of California. 1979. California water atlas. Sacramento. 118 pp.

Stebbins, R.C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Co., Boston. 278 pp.

Stiles, W.A., III. A brief review of natural revegetation in excavated stream channels. Santa Clara Valley Water District. 15 pp.

Strahan, J. 1984. Regeneration of riparian forests of the Central Valley. Pages 58-67 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Sudworth, G.B. 1967. Forest trees of the Pacific slope. Dover Publications, New York. 455 pp.

Sweet, S. 1983. Mechanics of a natural extinction event: Rana boylii in Southern California. Abstract. 31st Annu. Meet. Herpetol. League, Salt Lake City, UT.

Swift, L.W., and J.B. Messer. 1971. Cuttings raise temperatures of small streams in the Southern Appalachians. J. Soil Water. Conserv. 26:111-116.

Syvertsen, J.P. 1974. Relative stem water potentials of three woody perennials in a southern oak woodland community. Bull. South. Calif. Acad. Sci. 73:108-113.

Tate, J., Jr., and D.J. Tate. 1982. The blue list for 1982. Am. Birds 36:126-135.

Taylor, B.D. 1983. Sediment yields in coastal Southern California. Am. Soc. Civil Eng. J. Hydrol. Eng. 109(1):71-85.

Teskey, R.O., and T.M. Hinckley. 1980. Impact of water level changes on woody riparian and wetland communities. Vol. 1. Plant and soil responses to flooding. U.S. Fish Wildl. Serv. Off. Biol. Serv. FWS/OBS-77/58.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1978. Riparian zones in managed rangelands--their importance to wildlife. Pages 21-31 in O.B. Cope, ed. 1979. Proceedings of a forum - grazing and riparian/stream ecosystems. Trout Unlimited, Inc. Denver.

Thorne, R.F. 1967. A flora of Santa Catalina Island, California. Aliso 6(3):1-77.

Thorp, R.W., D.S. Horning, Jr., and L.L. Dunning. 1983. Bumble bees and cuckoo bumble bees of Calif. Bull. Calif. Insect. Surv. 23:1-79.

Tietz, H.M. 1972. An index to the described life histories, early stages and hosts of the macrolepidoptera of the continental U.S. and Canada. Vols. 1 & 2. A.C. Allyn, Sarasota, FL. 1041 pp.

Toweill, D.E., and J.G. Teer. 1980. Homerange and den habits of Texas Ringtails (Bassariscus astutus) in Proc. Worldwide Furbearer Conf. Vol. I-III. Baltimore, MD.

Troeschler, R.G. 1976. Acorn woodpecker breeding strategy as affected by Starling nest-hole competition. Condor 78:151-166.

Tuinstra, K.E. 1967. Vegetation of the floodplains and first terraces of Rock Creek, near Red Lodge, Montana. Ph.D. Thesis. Montana State University, Bozeman. 110 pp.

U.S. Army Corps of Engineers, Los Angeles District. 1981. San Luis Rey River. GDM main report, supplemental final E.I.S. 233 pp. and appendixes.

U.S. Council on Environmental Quality. 1978. Environmental Quality. The Ninth Annual Report of the Council of Environmental Quality. U.S. Government Printing Office, Washington, DC [Stock No. 041-011-00040-8]. 599 pp.

U.S. Fish and Wildlife Service. 1982. Republication of the lists of endangered and threatened species. Fed. Reg. 48:34182-34196.

U.S. National Park Service. 1983. Draft Land Protection Plan for the Santa Monica Mountains. Santa Monica Mountains National Recreational Area. 75 pp.

U.S. Forest Service. 1984. San Bernardino National Forest Wetland Study, Order III Stream Survey, Vegetation Mapping, Series Level. (Reports and maps on file in U.S. Riverside office.)

Unitt, P. 1984. The birds of San Diego County. San Diego Museum of Natural History, San Diego. 276 pp.

Usinger, R.L. 1956. Aquatic Hemiptera. Pages 182-228 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Vannote, R.L., G.W. Minshall, K.W. Cummmins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130-137.

Vaughn, T.A. 1954. Mammals of the San Gabriel Mountains. Univ. Kan. Publ. Mus. Nat. Hist. 7(9):513-582.

Verner, J. 1979. Birds of California's oak habitats--management implications. Pages 246-264 in T.R. Plumb, tech. coord. Proc. symposium on ecology, management and utilization of California oaks. U.S. For. Serv. Pacific SW Forest & Range Exp. Sta., Berkeley.

Verner, J., and L. Ritter. 1983. Current status of the brown-headed cowbird in the Sierra National Forest. Auk 100:355-369.

Vogl, R.J. 1976. An introduction to the plant communities of the Santa Ana and San Jacinto Mountains. Pages 77-91 in J. Latting, ed. Symposium proceedings: plant communities of Southern California. Calif. Native Plant Soc. Spec. Pub. 2.

Vogl, R.J. 1980. The ecological factors that produce perturbation-dependent ecosystems. In J. Cairns, Jr., ed. The recovery process in damaged ecosystems. Ann Arbor Science, Ann Arbor, MI.

Walters, M.A., R.O. Teskey, and T.M. Hinckley. 1980. Impact of water level changes on woody riparian and wetland communities, Vol. VII, Mediterranean Region and Western Arid and Semi-arid Region. U.S. Fish Wildl. Serv., Off. Biol. Serv., FWS/OBS-78/93.

Warner, R. 1983. Riparian resources of the Central Valley & California Desert: a report on their nature, history, status, and future (Draft). California Department of Fish and Game, Sacramento, CA. 231 pp.

Wauer, R.H. 1977. Significance of the Rio Grande riparian systems upon the avifauna. U.S. For. Serv., Gen. Tech. Rep. RM-43:165-174.

Webster, R., P. Lehman, and L. Bevier. 1980. The birds of Santa Barbara and Ventura Counties. Santa Barbara Mus. Nat. Hist. Occ. Pap. 10.

Weislander vegetation type maps. 1929-1935. Pacific Southwest Forest and Range Experiment Station, Berkeley.

Wells, S., and L.F. Baptista. 1979. Breeding of Allen's Hummingbird (Selasphorus sasin sedentarius) on the Southern California mainland. West. Birds 10:83-85.

Wheeler, G.P., and J.M. Fancher. 1984. San Diego County riparian systems: current threats and statutory protection efforts. Pages 838-843 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

Whittaker, R.H., and W.A. Niering. 1975. Vegetation of the Santa Catalina Mountains, Arizona: a gradient analysis of the south slope. Ecology 46:429-452.

Wilbur, S.R. 1974. The literature of the California Black rail. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 179.

Wilcox, C., and B.W. Massey. 1983. Winter bird census, riparian woodland and freshwater marsh, Orange County, CA. Am. Birds 37:45.

Willet, G. 1933. Revised list of the birds of southwestern California. Pacific coast Avifauna 21. Cooper Ornithological Society.

Williams, P. 1979. The E.I.R. process as a tool for implementing flood plain management policies. DWR Flood Manage. Conf. Rep. No. 44 SSN0575-4968.

Williams, T. 1983. Country doctor helps sick streams rush back to life. Smithson. Mag. 14(2):72-78.

Winegar, H. 1977. Camp Creek channel fending--plant, wildlife, soil and water response. Rangeman's J. 4(1):10-12.

Winterbourn, M.J. 1971. An ecological study of Banksoila crotchi banks

(Trichoptera: Phryganeidae) in Marion Lake, British Columbia. Can. J. Zool. 49:637-645.

Wirth, W., and A. Stone. 1956. Aquatic Diptera. Pages 372-482 in R.L. Usinger, ed. Aquatic insects of California. University of California Press, Berkeley.

Wooding, J. 1973. Census of the breeding birds of the Roaring Creek watershed. Col. Field Ornithol. 18:36-41.

Yanev, K.P. 1980. Biogeography and distribution of three parapatric salamander species in coastal and borderland California. In D.M. Power, ed. The California Islands: proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History.

Yeager, L.E. 1955. Two woodpecker populations in relation to environmental change. Condor 57:148-153.

Zembal, R. 1984a. Survey of vegetative and vertebrate fauna in the Prado Basin and the Santa Ana River Canyon, CA. U.S. Army Corps of Engineers, Los Angeles.

Zembal, R. 1984b. Fish & Wildlife Coordination Act Report, Santa Margarita River Project, San Diego County, CA. U.S. Bur. Reclamation, Lower Colorado Region, Boulder City, NV. Biol. Op. 1-1-84-F-9.

Zembal, R., and K. Kramer. 1984. The known distribution and unknown future of Santa Ana River wooly-star (Aeriostrum). Crossosoma 10(5):1-8.

Zentner, J. 1984. Protection of riparian systems in the California coastal zone. Pages 634-642 in R.E. Warner and K.M. Hendrix, eds. California riparian systems: ecology, conservation, and productive management. University of California Press, Berkeley.

APPENDIX A

Birds That Breed in Riparian Habitat in Coastal Southern California.

Name	Habitat[a] V	M	LM	Sources[b]	Status/Dependency	
Pied-billed grebe, *Podilymbus podiceps*			x	1,2,3,4,5,7	R	1
Eared grebe, *Podiceps nigricollis*			x	1,2,4,7	R	1
Western grebe, *Aechmophorus occidentalis*			x	1,2,4	R	1
American bittern, *Botaurus lentiginosus*			x	1,2,4	R	1
Least bittern, *Ixobrychus exilis*			x	1,2	R	1
Great blue heron, *Ardea herodias*	x	x	x	2,4,6,7	R	3
Great egret, *Casmerodius albus*			x	1	R	2
Snowy egret, *Egretta thula*			x	1,2,4,7	R	2
Cattle egret, *Bubulcus ibis*	x		x	1,2,4	R	2
Green-backed heron, *Butorides striatus*	x		x	1,2,4,5,6,7	R	1
Black-crowned night heron, *Nycticorax nycticorax*	x		x	1,2,4,7	R	3
White-faced ibis, *Plegadis chihi*			x	1,2	R	2
Wood duck, *Aix sponsa*	x			1,3,7	R	1
Mallard, *Anas platyrhynchos*			x	1,2,3,4,6,7	R	1
Northern pintail, *Anas acuta*			x	1,2,4,7	R	1
Cinnamon teal, *Anas cyanoptera*			x	1,2,4,5,6,7	R	1
Northern shoveler, *Anas clypeata*			x	1,6	R	1
Gadwall, *Anas strepera*			x	1,2,4,7	R	1
Redhead, *Aythya americana*			x	1,2,4,5	R	1
Ruddy duck, *Oxyura jamaicensis*			x	1,2,3,4,5,7	R	1
Black-shouldered kite, *Elanus caeruleus*	x			1,2,4,5,6,7	R	2
Northern harrier, *Circus cyaneus*			x	1,2,4,5,7	R	2
Cooper's hawk, *Accipiter cooperii*	x	x		1,2,4,5,7	R	2
Red-shouldered hawk, *Buteo lineatus*	x			1,2,3,4,5,6,7	R	1
Red-tailed hawk, *Buteo jamaicensis*	x	x		1,2,3,4,5,6,7	R	3
Americen kestrel, *Falco sparverius*	x	x		1,2,3,4,5,6,7	R	3
California quail, *Callipepla californica*	x	x		1,2,3,4,5,6,7	R	3
Mountain quail, *Oreortyx pictus*		x		2,7	R	3
Black rail, *Laterallus jamaicensis*			x	1,2	R	1
Virginia rail, *Rallus limicola*			x	1,2,4,5,6,7	R	1
Sora, *Porzana carolina*			x	1,2	R	1
Common moorhen, *Gallinula chloropus*			x	2,4,5	R	1
American coot, *Fulica americana*			x	1,2,3,4,5,6,7	R	1
Killdeer, *Charadrius vociferus*			x	1,2,3,4,5,6,7	R	2
Black-necked stilt, *Himantopus mexicanus*			x	1,2,4,5,6,7	R	2
American avocet, *Recurvirostra americana*			x	1,2,5,7	R	2
Spotted sandpiper, *Actitis macularia*	x		x	1,2,4,6,7	R	1
Common snipe, *Gallinago gallinago*			x	1	R	1
Band-tailed pigeon, *Columba fasciata*		x		1,3,4,7	R	3
Spotted dove, *Streptopelia chinensis*	x			3	R	3
Mourning dove, *Zenaida macroura*	x	x		1,2,3,4,5,6,7	R	3
Common ground dove, *Columbina passerina*	x			1,2,4	R	2
Yellow-billed cuckoo, *Coccyzus americanus*	x			1,2,6	M	1
Common barn owl, *Tyto alba*	x			1,2,4,5,6	R	3

(Continued)

Name	Habitat[a] V	M	LM	Sources[b]	Status	Dependency
Flammulated owl, Otus flammeolus	x			2	R	4
Western screech owl, Otus kennicottii	x			1,2,4,5,7	R	3
Great horned owl, Bubo virginianus	x	x		1,2,3,4,5,7	R	3
Northern pygmy owl, Glaucidium gnoma	x			1,4,7	R	3
Spotted owl, Strix occidentalis		x		1,2,4,7	R	3
Long-eared owl, Asio otus	x			1,5,7	R	1
Northern saw-whet owl, Aegolius acadicus	x	x		1,2,4,7	R	2
Black swift, Cypseloides niger		x		1,2	M	1
Black-chinned hummingbird, Archilochus alexandri	x	x	x	1,2,3,4,5,6,7	M	2
Anna's hummingbird, Calypte anna	x	x	x	1,2,3,4,5,6,7	R	3
Costa's hummingbird, Calypte costae	x			1,3,5,6,7	R	3
Calliope hummingbird, Stellula calliope		x	x	1,2,7	M	2
Allen's hummingbird, Selasphorus sasin	x	x		1,2,3,7	R	2
Belt kingfisher, Ceryle alcyon	x	x		1,2,5,6,7	R	2
Acorn woodpecker, Melanerpes formicivorus	x	x		1,2,3,4,5,6,7	R	2
Red-breasted sapsucker, Sphyrapicus ruber		x		1,2,4,7	R	2
Nuttall's woodpecker, Picoides nutallii	x	x		1,2,3,4,5,6,7	R	2
Downy woodpecker, Picoides pubescens	x			1,2,3,4,5,6,7	R	1
Hairy woodpecker, Picoides villosus	x	x		1,2,3,4,7	R	3
Northern flicker, Colaptes auratus	x	x		1,2,3,4,5,6,7	R	2
Olive-sided flycatcher, Contopus borealis	x	x		1,2,4,7	M	2
Western wood pewee Contopus sordidulus	x	x		1,2,3,4,5,6,7	M	3
Willow flycatcher, Empidonax traillii	x	x		1,2,4,5,6	M	1
Western flycatcher, Empidonax difficilis	x	x		1,2,3,4,5,6,7	M	2
Black phoebe, Sayornis nigricans	x	x		1,2,3,4,5,6,7	R	2
Ash-throated flycatcher, Myiarchus cinerascens	x			1,2,3,4,5,6,7	M	3
Cassin's kingbird, Tyrannus vociferans	x			2,3,5,6,7	M	3
Western kingbird, Tyrannus verticalis	x			2,3,4,5,6	M	3
Purple martin, Progne subis	x			1,2,4,7	M	2
Tree swallow, Tachycineta bicolor	x	x		1,2,3,4,6,7	M	2
Violet-green swallow, Tachycineta thalassina	x	x		1,2,3,4,7	M	3
Northern rough-winged swallow, Stelgidopteryx serripennis	x		x	1,2,3,4,5,6,7	M	3
Bank swallow, Riparia riparia	x		x	2	M	2
Cliff swallow, Hirundo pyrrhonota	x	x	x	1,2,3,4,5,6,7	M	3
Barn swallow, Hirundo rustica	x		x	1,2,4,7	M	2
Steller's jay, Cyanocitta stelleri		x		1,2,4,7	R	3
Scrub jay, Aphelocoma coerulescens	x			3,4,5,6,7	R	3
Yellow-billed magpie, Pica nuttalli	x			1,2,7	R	2
American crow, Corvus brachyrhynchos	x			1,2,3,4,5,7	R	2
Common raven, Corvus corax	x			4,5	R	4
Chestnut-backed chickadee, Parus rufescens	x	x		1,2,7	R	2
Plain titmouse, Parus inornatus	x	x		1,2,3,4,5,6,7	R	2
Bushtit, Psaltriparus minimus	x	x		1,2,3,4,5,6,7	R	3
White-breasted nuthatch, Sitta carolinensis	x	x		2,3,4,7	R	3
Brown creeper, Certhia americana		x		1,4,7	R	3
Canyon wren, Catherpes mexicanus	x	x		1,2,4,5,7	R	3

(Continued)

Appendix A. (Continued)

Name	Habitat[a] V	M	LM	Sources[b]	Status/Dependency	
Bewick's wren, *Thryomanes bewickii*	x	x		1,2,3,4,5,6,7	R	3
House wren, *Troglodytes aedon*	x	x		1,2,3,4,5,6,7	R	2
Marsh wren, *Cistothorus palustris*			x	1,2,4,5,6	R	1
American dipper, *Cinclus mexicanus*	x	x		1,2,7	R	1
Blue-gray gnatcatcher, *Polioptila caerulea*	x			1,2,5,7	R	3
Western bluebird, *Sialia mexicana*	x			1,2,4,7	R	3
Townsend's solitaire, *Myadestes townsendi*		x		1,2	R	2
Swainson's thrush, *Catharus ustulatus*	x			1,2,4,5,6,7	M	1
American robin, *Turdus migratorius*	x	x		1,2,3,7	R	3
Wrentit, *Chamea fasciata*	x			3,5	R	4
Northern mockingbird, *Mimus polyglottos*	x			3,6	R	4
California thrasher, *Toxostoma redivivum*	x			1,2,3,5,6,7	R	3
Phainopepla, *Phainopepla nitens*	x			1,2,3,4,5,7	R	2
Loggerhead shrike, *Lanius ludovicianus*	x			3,5	R	3
European starling, *Sturnus vulgaris*	x			2,3,4,5,6,7	R	3
Least Bell's vireo, *Vireo bellii pusillus*	x			1,2,4,5,6,7	M	1
Solitary vireo, *Vireo solitarius*	x	x		2,4,7	M	2
Hutton's vireo, *Vireo huttoni*	x	x		1,2,3,4,5,7	M	2
Warbling vireo, *Vireo gilvus*	x	x		1,2,3,4,5,7	M	2
Orange-crowned warbler, *Vermivora celata*	x	x		1,2,3,4,5,7	M	3
Yellow warbler, *Dendroica petechia*	x	x		1,2,3,4,5,6,7	M	1
MacGillivray's warbler, *Oporornis tolmiei*		x		1,2	M	1
Common yellowthroat, *Geothlypis trichas*	x		x	1,2,3,4,5,6,7	R	1
Wilson's warbler, *Wilsonia pusilla*	x	x	x	1,2,7	M	1
Yellow-breasted chat, *Icteria virens*	x			1,2,4,5,6,7	M	1
Black-headed grosbeak, *Pheucticus melanocephalus*	x	x		1,2,3,4,5,6,7	M	2
Blue grosbeak, *Guiraca caerulea*	x			1,2,4,6,7	M	2
Lazuli bunting, *Passerina amoena*	x	x		1,2,6,7	M	2
Rufous-sided towhee, *Pipilo erythrophthalmus*	x	x		1,2,3,4,5,6,7	R	2
Brown towhee, *Pipilo fuscus*	x			2,3,5,6,7	R	3
Fox sparrow, *Passerella iliaca*		x		1	R	2
Song sparrow, *Melospiza melodia*	x	x	x	1,2,3,4,5,6,7	R	1
Lincoln's sparrow, *Melospiza lincolnii*	x	x		1,2	R	1
Dark-eye junco, *Junco hyemalis*	x	x	x	3	R	3
Red-winged blackbird, *Agelaius phoeniceus*	x	x	x	1,2,3,4,5,6,7	R	2
Tri-colored blackbird, *Agelaius tricolor*			x	1,2,4,7	R	2
Western meadowlark, *Sturnella neglecta*			x	2,3,5	R	4
Yellow-headed blackbird, *Xanthocephalus xanthocephalus*			x	1,2	R	1
Great-tailed grackle, *Quiscalus mexicanus*	x		x	6	R	3
Brewer's blackbird, *Euphagus cyanocephalus*	x	x	x	1,2,3,4,6,7	R	3
Brown-headed cowbird, *Molothrus ater*	x			1,2,3,4,5,6,7	R	2
Hooded oriole, *Icterus pectoralis*	x			1,2,3,4,5,6,7	M	3
Northern oriole, *Icterus galbula*	x	x		1,2,3,4,5,6,7	M	2
Purple finch, Carpodacus *purpureus*	x	x		1,2,3,4,7	R	2
Cassin's finch, *Carpodacus cassinii*		x		2,7	R	3
House finch, *Carpodacus mexicanus*	x	x	x	1,2,3,4,5,6,7	R	4

(Continued)

Appendix A. (Concluded)

Name	Habitat[a] V	M	LM	Sources[b]	Status/Dependency	
Lesser goldfinch, Carduelis psaltria	x	x		1,2,3,4,5,6,7	R	3
Lawrence's goldfinch, Carduelis lawrencei	x	x		1,2,4,5,7	R	2
American goldfinch, Carduelis tristis	x	x		1,2,3,4,5,6,7	R	2
House sparrow, Passer domesticus	x	x	x	2,3,6	R	3

[a] - Habitat: V = valleys; M = montane; LM = lakes, marshes, wet meadows.
[b] - Sources: 1 = Garrett and Dunn, 1981; 2 = Keeney and Loe, 1984; 3 = Onuf, 1983; 4 = Unitt, 1984; 5 = Zembal, 1984a; 6 = Zembal, 1984b; 7 = Webster et al., 1980.

Seasonal Status: R = Resident; M = Migrant

Riparian Dependency: 1 = obligate riparian nesters
2 = riparian habitat preferred for nesting, but other habitats used
3 = variety of habitats used for nesting, including riparian
4 = riparian habitat occasionally used

APPENDIX B

Birds That Use Riparian Habitat for Other Than Breeding Purposes[a]

Name	Habitat[b] V	L	LM	Season[c]
Red-throated loon, *Gavia stellata*			x	W
Double-crested cormorant, *Phalacrocorax auritus*			x	YR
Canada goose, *Branta canadensis*			x	W
Green-winged teal, *Anas crecca*			x	W
Blue-winged teal, *Anas discors*			x	W
American wigeon, *Anas americana*			x	w
Canvasback, *Aythya valisineria*			x	W
Ring-necked duck, *Aythya collaris*			x	W
Lesser scaup, *Aythya affinis*			x	W
Common goldeneye, *Bucephala clangula*			x	W
Bufflehead, *Bucephala albeola*			x	W
Common merganser, *Mergus merganser*			x	W
Red-breasted merganser, *Mergus serrata*			x	W
Turkey vulture, *Cathartes aura*	x	x		YR
Osprey, *Pandion haliaetus*			x	W
Bald eagle, *Haliaeetus leucocephalus*			x	W
Sharp-shinned hawk, *Accipiter striatus*	x	x		W
Rough-legged hawk, *Buteo lagopus*			x	W
Golden eagle, *Aquila chrysaetos*			x	W
Merlin, *Falco columbarius*	x	x	x	W
Prairie falcon, *Falco mexicanus*			x	W
Black-bellied plover, *Pluvialis squatarola*			x	W
Greater yellowlegs, *Tringa melanoleuca*			x	W
Lesser yellowlegs, *Tringa flavipes*			x	W
Willet, *Catoptrophorus semipalmatus*			x	W
Whimbrel, *Numenius phaeopus*			x	W
Long-billed curlew, *Numenius americanus*			x	W
Marbled godwit, *Limosa fedoa*			x	W
Western sandpiper, *Calidris mauri*			x	W
Least sandpiper, *Calidris minutilla*			x	W
Dunlin, *Calidris alpina*			x	W
Long-billed dowitcher, *Limnodromus scolopaceus*			x	W
Bonaparte's gull, *Larus philadelphia*			x	W
Heermann's gull, *Larus heermanni*			x	W
Mew gull, *Larus canus*			x	W
Ring-billed gull, *Larus delawarensis*			x	W
California gull, *Larus californicus*			x	W
Western gull, *Larus occidentalis*			x	W
Caspian tern, *Sterna caspia*			x	W
Forster's tern, *Sterna forsteri*			x	W
Short-eared owl, *Asio flammeus*	x			W
Vaux's swift, *Chaetura vauxi*	x	x	x	M
White-throated swift, *Aeronautes saxatalis*	x	x	x	W
Red-breasted sapsucker, *Sphyrapicus ruber*		x		YR
Say's phoebe, *Sayornis saya*	x			YR

(Continued)

APPENDIX B. (Concluded)

Name	Habitat[b] V	L	LM	Season[c]
Hammond's flycatcher, *Empidonax hammondii*	x	x		M
Dusky flycatcher, *Empidonax oherholseri*	x	x		M
Mountain chickadee, *Parus gambeli*	x	x		YR
Winter wren, *Troglodytes troglodytes*	x	x		W
Golden-crowned kinglet, *Regulus satrapa*	x	x		W
Ruby-crowned kinglet, *Regulus calendula*	x	x		W
Hermit thrush, *Catharus guttatus*	x	x	x	W
Water pipit, *Anthus spinoletta*			x	W
Cedar waxwing, *Bombycilla cedrorum*	x			W
Nashville warbler, *Vermivora ruficapilla*	x	x		M
Yellow-rumped warbler, *Dendroica coronata*	x	x		W
Black-throated gray warbler, *Dendroica nigrescens*	x	x		M
Townsend's warbler, *Dendroica townsendi*	x	x		M
Hermit warbler, *Dendroica occidentalis*	x			M
Black and white warbler, *Mniotilta varia*	x			M
Western tanager, *Piranga ludoviciana*	x	x		M
Green-tailed towhee, *Pipila chlorurus*	x			YR
Rufous-crowned sparrow, *Aimophila ruficeps*	x			W
Fox sparrow, *Passerella iliaca*	x		x	W
Lincoln's sparrow, *Melospiza lincolnii*	x		x	W
Golden-crowned sparrow, *Zonotrichia atricapilla*	x	x		W
White-crowned sparrow, *Zonotrichia leucophrys*	x			W

[a]Sources: Compiled from 25 winter bird population studies published in *American Birds*: 1975, 29(3):765; 1976, 30(6):1068; 1978, 32(1):39,40,41,44,45; 1979, 33(1):49; 1981, 35(1):29; 1982, 36(1):37,42,43; 1983, 37(1):45; 1984, 38(1):46,47,48,49,50,51.

[b]Habitat: V = Valley streams; M = montane streams; LM = lakes, marshes, wet meadows.

[c]Season: W = winter use; M = migrant; YR = year-round use.

APPENDIX C

Mammals Associated With Riparian Habitat in Coastal Southern California.

Name	Sources[a]	Dependency[b]	Comments
Virginia opossum, Didelphis virginiana	2,4,5,6,7,8,9	2	Introduced
Ornate shrew, Sorex ornatus	2,4,5,8,9	1	
Broad-footed mole, Scapanus latimanus	1,2,3,4,5,6,7,8	2	
California leaf-nosed bat, Macrotus waterhousii	2,4,5		
Yuma myotis, Myotis yumanensis	1,2,4		
Fringed myotis, Myotis thysanodes	4,5		
Long-legged myotis, Myotis volans	4,5		
Long-eared myotis, Myotis evotis	2,4		
California myotis, Myotis californicus	2,3,4,5,8		
Western pipistrelle, Pipistrellus hesperus	2,4,5,8		
Big brown bat, Eptesicus fuscus	2,3,4,5,8		
Red bat, Lasiurus borealis	4,5		
Hoary bat, Lasiurus cinereus	2,4,5		
Big-eared bat, Plecotus townsendii	4,5		
Mexican free-tailed bat, Tadarida brasilinensis	4,5		
Western mastiff bat, Eumops perotis	3,4,5,9		
Western grey squirrel, Sciurus griseus	3,4,5,9	3	Oak woodland
Northern flying squirrel, Glaucomys sabrinus	3,4,5	3	Pine forest
Botta's pocket gopher, Thomomys bottae	2,3,4,5,6,7,8,9	2	
Beaver, Castor canadensis	2,5,8	1	Introduced
Western harvest mouse, Reithrodontomys megalotis	4,5,6,8	2	
California mouse, Peromyscus californicus	2,4,5,8,9	2	
Deer mouse, Peromyscus maniculatus	2,3,4,5,6,8	2	
Brush mouse, Peromyscus boylii	2,3,4,5,7,8,9	2	
Pinyon mouse, Peromyscus trueii	3,4,5	3	All woodlands
Desert woodrat, Neotoma lepida	2,4,5,8,9	3	
Dusky-footed woodrat, Neotoma fuscipes	1,2,3,4,6,7,9	2	
California vole, Microtus californicus	1,2,3,4,5,7,9	1	
Porcupine, Erethizon dorsatum	4,5	3	All forests
Coyote, Canis latrans	2,4,5,6,7,8	3	All forests
Gray fox, Urocyon cinereoargenteus	2,3,4,5,6,8,9	3	Open forests
Red fox, Vulpes fulva	5	3	Introduced
Black bear, Ursa americanus	2,5,6	3	Introduced

(Continued)

Appendix C. (Concluded)

Name	Sources[a]	Dependency[b]	Comments
Ringtail, <u>Bassariscus astutus</u>	2,4,5,7,9	1	
Raccoon, <u>Procyon lotor</u>	2,4,5,6,7,8,9	1	
Long-tailed weasel, <u>Mustela frenata</u>	2,4,5,6,8	1	
Badger, <u>Taxidea taxus</u>	2,4,5,6,8	3	Open country
Spotted skunk, <u>Spilogale putorius</u>	2,4,5	2	
Striped skunk, <u>Mephitis mephitis</u>	2,3,4,5,6,7,8	2	
Mountain lion, <u>Felix concolor</u>	2,4,5,6,8	3	All forests
Bobcat, <u>Lynx fufus</u>	2,4,5,6,7,8	3	chaparral
Mule deer, <u>Odocoileus hemionus</u>	2,3,4,5,6,8	3	All forests

[a]Sources: 1 = requires or prefers riparian habitat
2 = found equally in riparian and other habitat
3 = uses riparian habitat but prefers other habitat

APPENDIX D

Examples of Riparian Habitat in Coastal Draining Watersheds of Southern California.

Santa Barbara County		
Location	Description	Access
Hollister Ranch (sea level to ridge)	Coastal streams many overgrazed	Permission required from Hollister Ranch, Gaviota
Rattlesnake Canyon (above Skofield County Park, Las Canoas Rd., Santa Barbara)	Relatively undisturbed riparian habitat	Walk-in access
Upper Santa Inez River (below Lake Cachuma, elevation 3,000 ft)	Ranching has eliminated most habitat except in river bed: few young trees	Inaccessible except by 4-wheel-drive or backpacking
Middle Santa Inez River (elevation 2,000 ft)	Several Forest Service campgrounds	Poor access road
Lower Santa Inez River (elevation 1,000 ft)	Intermittent creeks, Aliso and Oso Creeks	Easy road access to Los Prietos Ranger

Channel Islands		
Location	Description	Access
Santa Cruz Island	Best riparian habitat at Prisoner's Harbor, Valdez canyon: depauperate compared mainland	Contact The Nature Conservancy

Ventura River Watershed		
Location	Description	Access
Matilija Creek (elevation 3,000 ft	Willows, cottonwood California walnut	Good roadside access
Wheeler Gorge Campground (elevation 2,000 ft) Los Padres National Forest	Riparian corridor	Matilija Campground Nature Trail located along corridor, access to undisturbed areas
Ventura River Wash (elevation 650 ft)		Route 150 crosses wash

(Continued)

Santa Clara River		
Location	Description	Access
Piru Creek (elevation 2,600 ft) San Rafael Mountains above Lake Piru	Riparian corridor	Blue Point Campground in riparian corridor, access to undisturbed areas
Piru Creek (elevation 1,600 ft) below Lake Piru	Large willow stands	Roadside access
Piru Creek (elevation 1,000 ft)	Alluvial scrub along river terrace	Roadside access

Santa Monica Mountains (Santa Monica National Recreation Area)		
Location	Description	Access
Topanga Canyon Blvd., Topanga State Park	Alders in creek bottom; sycamores at wide points; walnut on north-facing canyon slopes	Roadside and park access
Las Tunas Canyon	Alders on stream edge, Cottonwood on higher terraces	roadside access
Cold Creek Canyon Nature Preserve	Willows dominate with oaks and sycamores on higher terraces; native wild grape	Roadside and preserve access
Mulholland Highway through Leo Carillo State Park	Large sycamores on upper terraces	Roadside access
Point Mugu State Park Big Sycamore Canyon	Canyon lined with sycamore, cottonwood, big-leaf maple, dogwood	Park access

San Gabriel River		
Location	Description	Access
Switzer Campground Angeles National Forest (elevation 3,300 ft)	Riparian assemblage in deep cut on north slope: alder, willow, sycamore, bay, oak	Angeles Crest Road off Highway 2

(Continued)

APPENDIX D (Continued)

San Gabriel River (Continued)		
Location	**Description**	**Access**
Chantry Flats (elevation 2,000 ft)	Well-developed riparian community with alder, cottonwood, bay	Above Arcadia in Santa Anita Canyon
San Gabriel River (elevation 1,000 ft) Santa Fe Regional Park	Good remnant of alluvial scrub habitat	Irwindale exit from Highway 210
Whittier Narrows Wildlife Sanctuary (elevation 300 ft)	277 acres of riparian habitat with many exotic species	Trail access

San Bernardino Mountains (Santa Ana River watershed)		
Location	**Description**	**Access**
Heartbar and Southfork Campground (elevation 6,600 ft)	Upper reaches of Santa Ana River; willow and Jeffrey pine	Campground access
Southfork Campground (elevation 6,200 ft)	Alder, willow, Jeffrey pine	Campground access
Mill Creek (elevation 4,000 ft)	Scattered alder, Cottonwood, willow, big-leaf maple, with sycamore and oak on higher terraces	Roadside access
Mountain Creek Home (elevation 4,000 ft)	Large alder grove	Roadside access
Mentone (elevation 2,000 ft)	Beginning of Santa Ana Wash fed by smaller creeks heavily scoured by 1932 and 1968 storms; alluvial scrub	Roadside access
Riverside Regional Park (elevation 700 ft)	Half-mile-wide riparian corridor; willow forest, cottonwood, sycamore, oak on higher terraces	Park access
River Road east of Corona above Prado Dam (elevation 500 ft)	Wide riparian corridor of willow thickets invaded by cane, cottonwood, sycamore	Limited roadside access

(Continued)

San Bernardino Mountains (Santa Ana River watershed) (Continued)		
Location	Description	Access
Featherly County Park (elevation 300 ft)	Remnants of riparian habitat with willow, wild grape,mulefat, cottonwood, large sycamores on higher terraces; many exotics	Gypsum Canyon Road near Yorba Linda

San Jacinto River		
Location	Description	Access
Fuller and Mill Creek (elevation 6,000 ft)	Willow, alder, azalea with Coulter and ponderosa pine near streams	Roadside access
Cranston Guard Station (elevation 2,000 ft)	Willow, mulefat, cotton-wood, large live oak on terrace above; coastal sage scrub on adjacent slopes	Roadside access east of Valle Vista off Route 74
Lamb Canyon (elevation 2,000 ft)	Large willows: cotton-wood, willow beside underground river	Roadside access

Santa Ana Mountains (Orange County)		
Location	Description	Access
Santiago Oaks Regional Park un Santiago Creek (elevation 1,000 ft)	Large oaks on upper terraces next to narrow riparian corridor	518 east of Garden Grove Freeway; walk-in access
O'Neill Regional Park on Trabuco Creek, north of El Toro (elevation 1,000 ft)	600 acres of overgrazed riparian corridor; handsome live oaks; Holy Jim Trail in nearby Cleveland National Forest leads to unusual alder grove, waterfall	Walk-in access
Caspers Wilderness Park on San Juan Creek (elevation 1,000 ft)	Sand mining has destroyed large sycamore and oak along creek terraces	Off Ortego Highway

(Continued)

Appendix D (Continued)

San Diego County (Santa Margarita River)		
Location	Description	Access
Santa Rosa Plateau (elevation 1,000 ft)	Willow thickets; very large sycamores, oaks on terraces above stream	Off Highway 79 near Near Temecula
Deluz Road (elevation 600 ft)	Relatively undisturbed riparian habitat with willow, cottonwood, oak sycamore, understory	Roadside access north of Fallbrook
Camp Pendleton (near sea level)	Sizable remnants of wide willow scrub forest with ponded areas	Permission required

San Diego County (San Luis Rey River)		
Location	Description	Access
Wilderness Gardens Preserve (elevation 1,000 ft)	Some willow, cottonwood, sycamore, oak in a park planted with exotics	Ten miles east of Interstate 5 on Highway 76
Bridge at Bonsall and along Highway 76 (elevation 170 ft)	Over 160 acres of coastal floodplain willow thicket with cottonwood, sycamore, freshwater marsh and riparian understory	Roadside access

San Diego County (Santa Ysabel Creeks)		
Location	Description	Access
Battle Monument (elevation 525 ft)	Good stands of willow and mulefat on river wash; most sycamore and oak removed	5 miles east of Wild Animal Park on Highway 78
Old Pasquale Road and San Pasquale Road (elevation 500 ft)	Willow thicket beside freshwater marsh	View from roadside only
Los Penesquitos Canyon Preserve	Five miles of riparian corridor with streamside willow and mulefat, ponded areas with cat-tail, and large sycamore and oak; some disturbance and exotics	Foot access from Black Mountain Road west of Interstate 15 to Soreno Valley Road Interstate 5

(Continued)

Appendix D (Continued)

San Diego County (Santa Ysabel Creeks) (Continued)		
Location	Description	Access
San Clemente Creek	Strip of handsome sycamores and oaks preserved between high bluffs and highway	Highway 52 connecting Interstates 5 and 805

San Diego County (San Diego River)		
Location	Description	Access
Cleveland National Forest, Wynola (elevation 3,000 ft)	Deep canyon with perennial water	Walk-in access from Highway 78
El Monte County Park east of Lakeside (elevation 750 ft)	Riparian habitat with large oaks on higher terraces	
Mission Trails Regional Park (elevation 300 ft)	Dense willow and mulefat thickets, cottonwood, large sycamores, oak on upper terraces; invaded by cane	Off Mission Gorge Road west of Santee on San Diego River

San Diego County (Sweetwater River)		
Location	Description	Access
Cuyamaca Ranch State Park (elevation 4,000 ft)	Alders, willow, good understory with wild rose and western choke cherry	Off Highway 79
Sloan Canyon on Dehesa Road off Highway 54 (elevation 1,300 ft)	Riparian corridor follows land contours; coastal sage scrub; alder, sycamore, ash	Roadside access
Otay Municipal Water District power plant (elevation 700 ft)	Thickets of willow, cottonwood, mulefat; cattail in ponded areas	Access road behind power plant near junction of 54 and 94

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

In the 200 years since California's settlement by Europeans, almost every river in Southern California has been channelized or dammed to allow development on the floodplains, causing the loss of a highly productive ecosystem. The riparian zone occurs along streambanks where soils are fertile and water is abundant; amphibians, reptiles, birds, and mammals all move back and forth across the riparian zone from streams into adjacent wetland and upland areas. Irreversible alterations of the riparian ecosystem result from the diversion or loss of transported water to the system through diking, damming, channelization, levee building, or road construction. Clearing for crops, grazing, or golf courses is potentially reversible as long as the water supply remains unaltered. Successful restoration work requires early agreement on project goals, site-specific restoration design, correct project implementation, enforcement of permit conditions, a maintenance and management program, and long-range monitoring.

17. Document Analysis a. Descriptors

Ecology, Habitat, Fauna, Flora, Ecosystem

b. Identifiers/Open-Ended Terms

Riparian, Southern California, Floodplain, Fluvial system, Hydrology, Restoration

c. COSATI Field/Group

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